Abstract

Image format (Laws, Adlington, Gale, Moreno-Martínez, & Sartori, 2007), ceiling effects in controls (Fung et al., 2001; Laws et al., 2005; Moreno-Martínez, & Laws, 2007; 2008), and nuisance variables (Funnell & De Mornay Davis, 1996; Funnell & Sheridan, 1992; Stewart, Parkin & Hunkin, 1992) all influence the emergence of category specific deficits in Alzheimer's dementia (AD). Thus, the predominant use of line drawings of familiar, everyday items in category specific research is problematic. Moreover, this does not allow researchers to explore the extent to which format may influence object recognition. As such, the initial concern of this thesis was the development of a new corpus of 147 colour images of graded naming difficulty, the *Hatfield Image Test* (HIT; Adlington, Laws, & Gale, 2009), and the collection of relevant normative data including ratings of: age of acquisition, colour diagnosticity, familiarity, name agreement, visual complexity, and word frequency. Furthermore, greyscale and line-drawn versions of the HIT corpus were developed (and again, the associated normative data obtained), to permit research into the influence of image format on the emergence of category specific effects in patients with AD, and in healthy controls.

Using the HIT, several studies were conducted including: (i) a normative investigation of the effects of category and image format on naming accuracy and latencies in healthy controls; (ii) an exploration of the effects of image format (using the HIT images presented in colour, greyscale, and line-drawn formats) and category on the naming performance of AD patients, and age-matched controls performing below ceiling; (iii) a longitudinal investigation comparing AD patient performance to that of age-matched controls, on a range of semantic tasks (naming, sorting, word-picture matching), using colour, greyscale, and line-drawn versions of the HIT; (iv) a comparison of naming in AD patients and age-matched controls on the HIT and the (colour, greyscale and line-drawn) images from the Snodgrass and Vanderwart (1980) corpus; and (v) a meta-analysis to explore category specific naming in AD using the Snodgrass and Vanderwart (1980) versus other corpora.

Taken together, the results of these investigations showed first, that image format interacts with category. For both AD patients and controls, colour is more important for the recognition of living

things, with a significant nonliving advantage emerging for the line-drawn images, but not the colour images. Controls benefitted more from additional surface information than AD patients, which chapter 6 shows results from low-level visual cortical impairment in AD. For controls, format was also more important for the recognition of low familiarity, low frequency items. In addition, the findings show that adequate control data affects the emergence of category specific deficits in AD. Specifically, based on within-group comparison chapters 6, 7, and 8 revealed a significant living deficit in AD patients. However, when compared to controls performing below ceiling, as demonstrated in chapters 7 and 8, this deficit was only significant for the line drawings, showing that the performance observed in AD patients is simply an exaggeration of the norm.

Chapter 1: Theories of Category-specificity and the Emergence of Category Specific Deficits in Alzheimer's Patients and Healthy Controls.

1.1 WHAT ARE CATEGORY SPECIFIC DISORDERS?

Category specific deficits refer, in very broad terms, to the relative preservation in performance on one category of objects compared to that on another. In the neuropsychological literature, category-specificity is typically discussed in terms of a functional or anatomical distinction between the semantic categories of living thing and nonliving thing concepts (for recent reviews see Capitani et al., 2003; Laws, 2005). This phenomenon was first documented over 60 years ago by Nielsen (1946), who reported two patients displaying opposing patterns of visual agnosia for living and nonliving things. Though his account was purely anecdotal, this was later supported by empirical reports of a similar nature (Warrington & McCarthy, 1983; Warrington & Shallice, 1984). For example, Warrington and McCarthy (1983) presented a case study of patient VER, who exhibited global dysphasia following a major left hemisphere infarction. Despite substantial impairment of comprehension and propositional speech, on matching-to-sample tasks, VER was found to show relatively preserved performance with living things such as foods, animals, and flowers, though she was severely impaired with items from the nonliving domain (common household objects): Warrington and McCarthy interpreted this as evidence of a category specific deficit for nonliving things. By contrast, in a later study conducted by Warrington and Shallice (1984), a deficit for living things emerged in four patients recovering from Herpes Simplex Encephalitis (HSE). This pattern of performance, has since emerged as the more prevalent profile in patients with a range of neurological impairments including HSE, Alzheimer's dementia (AD), stroke, and traumatic brain injury (Basso, Capitani, & Laiacona, 1988; Farah, Hammond, Mehta, & Radcliffe, 1989; Hart, Berndt, & Caramazza, 1985; Hart & Gordon, 1992; Hillis & Caramazza, 1991; McCarthy & Warrington, 1988; Pietrini et al., 1988; Sartori & Job, 1988; Sartori, Job, Miozzo, Zago, & Marchiori, 1993; Sheridan & Humphreys, 1993; Silveri & Gainotti, 1988; Silveri, Daniele, Giustolisi, & Gainotti, 1991;

Warrington & Shallice, 1984). Nevertheless, several studies document the opposite pattern of performance (Hillis & Caramazza, 1991; Sacchett & Humphreys, 1992; Warrington & McCarthy, 1987).

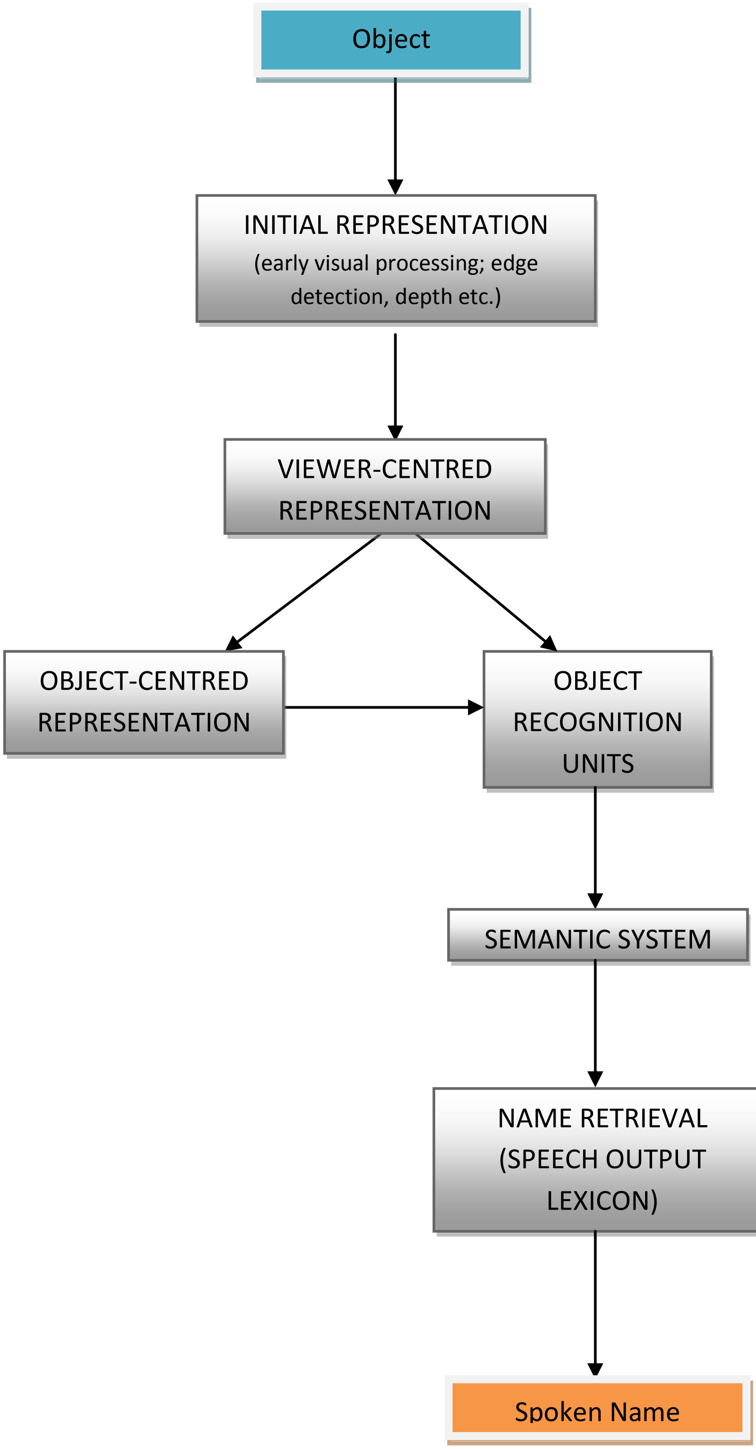


Figure 1.1 Model of object recognition adapted from Ellis & Young (1996).

The finding of category specific semantic impairments for living and nonliving things in neurologically impaired participants has underpinned several theories of semantic memory (semantic memory being defined as the repository for conceptual knowledge (Tulving, 1972), in which all non-contextual information relating to the meaning of words is stored, organised, and manipulated). However, these theories make little attempt to specify the criteria for a category specific impairment, particularly, what level of fractionation (i.e. living/nonliving, plant/animal etc.) may be accepted as evidence of category-specificity. Moreover, several recent papers have highlighted problems with the methods used to test category-specificity (e.g. Laws, Gale, Leeson, & Crawford, 2005; Laws, 2005), which may undermine the validity of the findings upon which some or all of these theories are based. Therefore, this chapter will explore theories of category specific semantic processing and the evidence upon which these models are based, and critically evaluate the methods used to test for category-specificity.

1.1.1 What constitutes a category specific impairment?

The majority of cases of category-specificity are for items from the living domain. A recent meta-analysis (Laws, Adlington, Gale, Moreno-Martínez, & Sartori, 2007a) of studies documenting category specific deficits in Alzheimer's dementia (AD) patients, noted that of the 21 studies that were suitable for analysis, 84% documented better performance (though not always significantly better) with nonliving things. Interestingly however, a comparison of the effect sizes obtained for living and nonliving things revealed that although the effect size for living things was larger than that for nonliving things (d=1.76 and d=1.49 respectively) the difference was not significant, showing that in AD at least, large and significant impairments emerge for both domains of processing. Furthermore, there was little difference in the number of studies reporting a larger effect size for living things compared to nonliving things (13 and 8 respectively). The authors account for the discrepancy between the number of studies reporting a living deficit, and the number reporting a larger effect size for living things, in relation to methodological factors, which are discussed in detail later in this chapter. Nevertheless, this demonstrates that the prevailing view that nonliving impairments are less likely to occur, may be something of a misconception.

Category specific deficits are commonly described as impairments for living or nonliving things; however, several studies report patients who exhibit further fractionations in performance. For example, there are reports of patients who show mixed category impairments, i.e. they are impaired with living things but also exhibit impaired performance with musical instruments, and gemstones (Silveri & Gainotti, 1988; Warrington & Shallice, 1984), or conversely, impaired with nonliving things but also perform poorly with body parts (see Barbarotto, Capitani, & Laiacona, 2001; Laws, Gale, Frank, and Davey, 2002 for discussion). In addition, there are reports of dissociations within domain. Thus, within the nonliving domain, patients have shown dissociations between large non-manipulable objects, and small manipulable objects (Warrington & McCarthy, 1987), and between indoor and outdoor objects (Yamadori & Albert, 1973). Concerning the living domain, there are reports of patients who exhibit better performance with fruits and vegetables than with animals (Caramazza & Shelton, 1998; Hart & Gordan, 1992), and vice versa (Hart, Berndt, & Caramazza, 1985; Hillis & Caramazza, 1991; Laws, Leeson, & Gale, 2002b). These studies therefore provide evidence of a double dissociation within the living domain.

In addition to reports of more fine-grained dissociations, there is evidence to suggest that category interacts with sex. Initial reports suggested that males performed better than females with items from the nonliving domain on tests of picture naming, object reality decision, and semantic fluency, whilst females showed the opposite, namely an advantage for living things (Barbarotto, Capitani, & Laiacona, 1996; Laiacona, Barbarotto, & Capitani, 1998; Laiacona, Luzzatti, Zonca, Guarnaschelli, & Capitani, 2000; Marra, Ferraccioli, & Gainotti, 2007; Moreno-Martínez, Laws, & Schulz, 2008). Several studies however, have revealed that this dissociation may be specific to certain subcategories of items. Indeed, in a large study of semantic fluency in 253 AD patients, Marra and co-workers (Marra, Ferracccioli & Gainotti, 2007) reported that female participants were less fluent than males for the subcategory of birds, but found no significant sex differences for furniture, thus showing a male advantage for items from one living subcategory. Moreover, a recent review by Gainotti (2005) of 48 (35 males, 13 females) single case studies showed that within-category sex differences were apparent, particularly when naming living things. Of those patients showing a selective impairment for fruits and vegetables, 18/19 were males, while 7/9 patients who showed a deficit for animals were females.

Case studies offer a valuable insight into the more fine-grained dissociations that are frequently overlooked by group studies. In particular, as reported by Gainotti (2005), case studies have revealed that male patients are more likely to show a disproportionate impairment for the recognition of plant life. For example, following an embolic stroke, male patient ELM, was more impaired at naming fruits and vegetables relative to animals (Arguin, Bub, & Dudek, 1996). Similarly, male patient MD showed a selective impairment for naming fruits and vegetables following a stroke though his ability to recognise items from all other categories was spared (Hart & Gordon, 1992). By contrast, female patient EW showed a selective impairment for animals following a stroke (Caramazza & Shelton, 1998). In accordance with this, a number of other female patients have been found to show a disproportionate impairment for animals (Gainotti & Silveri, 1996; Silveri & Gainotti, 1998). Nonetheless, a disproportionate impairment for animals has also been documented in a male patient (Farah, Hammond, Mehta, & Radcliff, 1989).

The studies discussed above demonstrate that the living-nonliving distinction commonly employed overlooks many of the more fine-grained dissociations that have emerged in the literature. Perhaps one reason for this is that researchers typically accept as true divisions, those dissociations that could intuitively denote separate cognitive domains. However, it is impossible to determine what actually represents a true dissociation without reference to theory (Van Orden, Pennington, & Stone, 2001) as it is necessary for the domains that emerge to in some way reflect those that are hypothesised. The ensuing sections will explore theories of semantic memory, which use as their foundation, category specific impairments.

1.2 THEORIES OF CATEGORY-SPECIFICITY

1.2.1 The Taxonomic Account

Possibly the simplest way to explain category specific deficits, is to suggest that the observed dissociations are a reflection of the underlying semantic categories. As focal brain lesions may impair the recognition of living things relative to that of nonliving things and vice versa, it could be concluded that semantic memory is organised taxonomically, and that focal damage to a specific region of the brain may impair processing of the concepts stored therein (e.g. Collins & Quillian, 1969; Laiacona, Capitani, & Barbarotto, 1997; Pietrini et al., 1988; Sartori & Job, 1988). This is in keeping with developmental studies of semantic organisation that have shown children around the ages of 6-7 years to use categorical/taxonomic organisational structures to organise concrete vocabulary concepts (e.g., Bauer & Mandler, 1989; Krackow & Gordon, 1998; Lucariello, Kyratzis, & Nelson, 1992; Nelson, 1996). However, several researchers have criticised this model because it contradicts existing evidence suggesting that brain systems are organised by modality and/or function (Martin, Haxby, Lalonde, Wiggs, & Ungerleider, 1995; Thompson-Schill, Aguirre, D'Esposito, & Farah, 1999). Furthermore, whilst a taxonomic approach can explain the more fine grained dissociations observed in the literature (e.g. Hart, Berndt, & Caramazza, 1985; Caramazza & Shelton, 1998; Hillis & Caramazza, 1991; Laws, Leeson, & Gale, 2002b; Silveri & Gainotti, 1988; Warrington & Shallice, 1984; Warrington & McCarthy, 1987; Yamadori & Albert, 1973), it fails to provide an a priori theory of how the specific patterns reported might have emerged, calling into question its usefulness as an explanation of category-specificity.

1.2.2 The Domain-specific Account

In contrast to the taxonomic approach, the domain-specific account posits that for those categories of items for which rapid identification confers reproductive advantages, natural selection has produced specialised, dissociable neural pathways (Caramazza & Mahon, 2003; Caramazza & Shelton, 1998; Mahon & Caramazza, 2003). In particular, it has been proposed that such pathways or 'modules' exist for animals, and plant life, with each containing functional and perceptual information relevant to the items stored therein. The domains of tools and conspecifics have more recently been incorporated into this account (Kay & Hanley, 1999; Miceli et al., 2000; Shelton, Fouch, & Caramazza, 1998). Thus, the model would account for category specific deficits as resulting from damage to the neural mechanism responsible for, or preferential in, the processing a particular category; for example, those responsible for the processing of animals (Caramazza & Shelton, 1998), or plants (Hart, Berndt, & Caramazza, 1985). This model might also account for the interaction between sex and subcategory. The division of labour model (Silverman & Eals, 1992) proposed that the specifically evolved social roles of males and females (males hunted animals while females foraged for plant-based foods) may have favoured the preferential processing of different domains, thus producing sexually dimorphic, specialised cognitive pathways (Gaulin, Krasnow, Truxaw, & New, 2005; McBurney, Gaulin, Devineni, & Adams, 1997; Silverman, Choi, Mackewn, Fisher, Moro, & Olshansky, 2000). In this way, these small sex asymmetries may continue to influence the acquisition and complexity of knowledge in certain domains (Geary, 1998; Laws, 2004).

In relation to sex differences in category-specificity, the domain-specific approach has been used to account for case studies in which males exhibit a deficit for fruits and vegetables relative to their performance with animals, whilst females show the opposite dissociation (for reviews see Gainotti, 2005; Laiacona, Barbarotto, & Capitani, 2006). Nevertheless, not all sex related differences are consistent with an evolutionary approach (Albanese, Capitani, Barbarotto, & Laiacona, 2000; Cameron, Wambaugh, & Mauszycki, 2008; Marra et al., 2007; McKenna & Parry, 1994). For example, the report of a sex-related dissociation between praxic and non-praxic objects (McKenna & Parry, 1994) is difficult to reconcile with an evolutionary approach, as this would not explain why females showed an advantage for large outdoor objects such as buildings. In addition, the results of Marra et al. (2007) showed superior healthy males performance with birds and females with furniture. In this instance, while the male advantage for animals is consistent with a domain-specific approach, it is unlikely that the female advantage for furniture could be attributed to a dedicated neural pathway as (i) furniture has only relatively recently become a part of our everyday lives, and (ii) it is unlikely that there would be any value in having a system devoted to the processing of furniture.

Though the domain-specific approach may account for some of the fine-grained dissociations observed in the literature, it cannot explain why there are very few reported dissociations between animals and plant life (Caramazza & Shelton, 1998; Hart, Berndt, & Caramazza, 1985; Hillis & Caramazza, 1991; Laws, Leeson, & Gale, 2002b), or why there appears to be a disproportionately large number of living thing cases compared to nonliving cases. Moreover, it cannot account for why participants displaying category specific deficits fail to score within the normal range on their preserved categories (e.g. Moss, Tyler, Durrant-Peatfield, & Bunn, 1998; Sartori & Job, 1988; Warrington & Shallice, 1984). Moss and Tyler (2003) propose that these findings suggest that category specific deficits are graded rather than all-or-nothing dissociations. In conjunction with this, they argue that evidence from neuroimaging studies negates the possibility of domain-specific semantic systems, as the variance in the extent and location of brain lesions is too great (Moss & Tyler, 2003). Indeed, whilst there are some studies that have reported differential activation of brain regions for the categories of animals and tools (Cappa, Frugoni, Pasquali, Perani, & Zorat, 1998; Chao, Haxby, & Martin, 1999; Haxby, Ungerleider, Clark, Schouten, Hoffman, & Martin, 1999; Martin, Wiggs, Ungerleider, & Haxby, 1996; Mummery, Patterson, Hodges, & Price, 1998; Perani et al, 1995, 1999) there is much variation in the sites of activation for these categories. Moreover, lesion location does not appear to distinguish between impairment for animals, and impairment for fruits and vegetables (Gainotti, 2005). In association with this, an analysis of the CT and MRI scans of herpes simplex encephalitis patients failed to show any correlation between the area of brain injury and the behavioural deficits observed, as damage was too widespread (Pietrini et al., 1988). Furthermore, studies reporting differential activation of brain regions according to category might actually be measuring activation resulting from the different kinds of interpretation needed to process items from different categories, such as social or mechanical attributes (Martin & Weisberg, 2003).

1.2.3 Artefactual Accounts

In contrast to the theories discussed thus far, which attribute the living-nonliving distinction to dissociable subsystems within semantic memory, the artefactual account of category-specificity suggests that dissociations in the recognition of living and nonliving things may be an artefact of uncontrolled item variables (Funnell & Sheridan, 1992; Stewart, Parkin, & Hunkin, 1992). This view specifically emphasises deficits for living things, suggesting that the greater proportion of living thing deficits reported in the literature may be attributed to the greater cognitive effort needed to process items from this domain. Indeed, Warrington and McCarthy (1983) claimed that living things tend to have lower concept familiarity and word frequency, and be more visually complex than nonliving things. Normative ratings obtained for the Snodgrass and Vanderwart (1980) corpus of images support this notion (this comprises of 260 line drawings of everyday objects from a range of living and nonliving subcategories). Accordingly, it has been argued that the normal pattern in neuropsychological studies would be to find more living thing impairments (Laws, Crawford, Gnoato & Sartori, 2007b; Tippett, Meier, Blackwood & Diaz-Asper, 2007). Nevertheless, it is important to note that this account cannot be reconciled with studies that report a disadvantage for nonliving things (Hillis & Caramazza, 1991). Arguably, a separate and opposing artefactual account would be necessary to explain nonliving deficits (Laws, 2004).

The notion that living thing deficits are an artefact of uncontrolled variables has received some support. Funnell and Sheridan (1992), described patients whose category specific semantic impairments disappeared when visual complexity and concept familiarity were controlled across category. In particular, they noted that the category specific deficit for living things exhibited by patient J.B.R, as reported by Warrington and Shallice (1984), was significantly influenced by the familiarity of the items. In light of this, they suggested that failure to control for familiarity might explain the relatively high number of living impairments reported in the literature. Nevertheless, a more recent study of J.B.R (Bunn, Tyler & Moss, 1998) did not replicate this finding, reporting instead a significant category effect across all levels of familiarity (i.e. the category effect remained significant across four familiarity bands, other than for the least familiar items, on which J.B.R's performance was at floor level).

Further studies have also shown that category effects persist even when the effects of nuisance variables are controlled (Hart & Gordon, 1992; Laiacona, Barbarotto, Trivelli, & Capitani, 1993; Caramazza & Shelton, 1998; Lambon-Ralph, Howard, Nightingale, & Ellis, 1998; Moss, Tyler, Durrant-Peatfield, & Bunn, 1998; Samson, Pillon, & De Wilde, 1998). However, there is great variation in the number and type of variables matched in studies of category-specificity (see table 1.1 for an example of the variance just within studies of AD patients). Moreover, recent findings suggest that closeness of matching may also influence the emergence of category effects in patient performance. Tippett, Meier, Blackwood and Diaz-Asper (2007) demonstrated that the living thing deficit noted when using stimuli that were loosely matched for familiarity (t=1.55; *p*=0.15), disappeared when items were more tightly matched on this variable (t=0.35; *p*=.73).

Table 1.1 Variables controlled (+) in group studies of AD patients. Adapted from Laws et al., (2007a).

Study	**Nuisance variables controlled**										
	AoA	Fam	Freq	IA	Img	LF	LW	NA	NAc	Pro	VC
Silveri et al. (1991)						+				+	
Montanes et al. (1995)											+
Tippett et al. (1996) set 1, 2 & 3		+				+[1,2,3]				+[1,3]	+[3]
Gonnerman et al. (1997) Exp 1 & 2			+							+	
Garrard et al. (1998)						+				+	
Laiacona et al. (1998)	+	+[i]		+[i]		+				+[i]	+[i]
Grossman et al. (1998)						+					
Garrard et al. (2001)	+	+				+				+	
Chan et al. (2001)		+				+					+
Fung et al. (2001)		+				+			+		+
Silveri et al. (2002)	+	+[i]				+	+	+		+[i]	

Study	Nuisance variables controlled										
	AoA	Fam	Freq	IA	Img	LF	LW	NA	NAc	Pro	VC
Zannino et al. (2002)	+	+		+[i]		+		+		+[i]	+[i]
Whatmough et al. (2003)		+							+		
Perri et al. (2003)		+[i]		+[i]		+		+		+[i]	+[i]
Laws et al. (2003)		+				+					
Harley & Grant (2004)	+	+					+	+			+
Cuetos et al. (2005)	+	+				+	+				
Laws et al. (2005) Exp 1, 2a, & 2b		+[1,2a,2b]				+[1,2a,2b]					+[1,2a]
Zannino et al. (2006)	+	+				+					+
Laws et al., 2007b		+						+			+
Moreno-Martínez Tallón-Barranco & Frank-Garcia,(2007)	+	+	+			+		+		+	+
Tippett et al., (2007) expts 1, 2 & 3	+[2]	+[1&3]				+[1&2]		+[2]	+[2]		+[1]
Zannino et al., (2007)	+	+				+					+
Hernandez et al., (2008)		+	+							+	
Moreno-Martínez & Laws, (2008)	+	+				+		+		+	+
Gale et al., (2009)	+	+				+			+		+
Adlington, Laws, & Gale, in press	+	+				+		+			+

Note: AoA = age of acquisition, Fam = familiarity, Freq = wall street Journal Frequency counts, IA = image agreement, Img = imageability, LF = lexical frequency, LW = length of word, NA = name agreement, NAc = name accuracy, Pro = prototypicality, VC = visual complexity. [i] according to English speaking norms.

Within the study of AD patients at least, the findings of Tippett and co-workers (Tippett et al., 2007) provide further support for the notion that category specific deficits for living things are an artefact of uncontrolled variables. Moreover, their findings suggest that with stringent control over potentially confounding factors, category effects may fail to emerge; and this has now been shown in several investigations (Cuetos, Dobarro, & Martínez, 2005; Hodges, Salmon, & Butters, 1992; Laiacona et al., 1998; Montanes et al., 1995; Moreno-Martínez et al., 2007; Moreno-Martínez, Laws, Goñi-Imizcoz, & Sanchez Martínez, 2008; Moreno-Martínez & Laws, 2008; Perri et al., 2003; Tippett et al., 1996; Tippett et al., 2007). As such, this has prompted some researchers to conclude that living-nonliving dissociations result from variations in nuisance variables, rather than the effect of category itself (Moreno-Martínez, Laws, Goñi-Imízcoz & Sanchez-Martínez, 2008). However, several studies have shown that category specific deficits persist even when stringent control of intrinsic variables is employed (Farah & McClelland, 1991; Gainotti & Silveri, 1996; Gale, Irvine, Laws, & Ferrissey, 2009; Kolinsky et al., 2002; Laiacona et al., 1993; 1997; Moreno-Martínez & Laws, 2007; Sartori, Miozzo & Job, 1993; Silveri, Gainotti, Perani, Cappelletti, Carbone, & Fazio, 1997; Zannino et al., 2002). Indeed, Gale and co-workers (Gale, Irvine, Laws & Ferrissey, 2009), demonstrated that despite matching items across domain for concept familiarity, visual complexity, and word frequency, AD participants still performed significantly worse with living things than with nonliving things. This suggests that intrinsic variables cannot solely account for the presence of category effects, at least within AD participants. Interestingly, Gale and colleagues also conducted a hierarchical regression analysis, including as predictors; nuisance variables (i.e. concept familiarity, visual complexity, word frequency, and age of acquisition), category (living/nonliving), and elderly control group performance. The regression analysis revealed that despite matching across category all variables except age of acquisition, nuisance variables still accounted for the largest proportion of the variance in patient naming (39%). By contrast, depending on the order in which the variables were entered into the model, category was found to account for just 3-10% of the variance in patient naming. This suggests that whilst an independent effect of category may be present, the effects of intrinsic item variables and normal tendencies can be much more substantial.

1.2.4 The Visual Crowding Hypothesis

Consistent with the artefactual account of category-specificity, proponents of the visual crowdedness hypothesis (VCH; Gaffan & Heywood, 1993; Gale, Done, & Frank, 2001; Humphreys et al., 1988, 1995) argue that deficits for living things may be due to the greater effort required to process items from this domain. Specifically, they suggest that living things have greater intra-category structural similarity (visual crowding) than nonliving things, making it more difficult to discriminate between items from the living domain. Consequently, the processing of living things may be more susceptible to lesions of areas involved in visual object processing. This is supported by evidence from neurological case studies, of patients who show impaired recognition of living things relative to nonliving things following damage to occipitotemporal regions, and in spite of relatively preserved semantic knowledge (e.g. AN (Funnell, 2000); ELM (Arguin, Bub, & Dudek, 1996; Dixon, Bub, & Arguin, 1998); FB (Sirigu, Duhamel, & Poncet, 1991); Felicia (De Renzi & Lucchelli, 1994); HJA (Riddoch & Humphreys, 1987b); LH (Etcoff, Freeman, & Cave, 1991; Farah, Hammond, Mehta, & Ratcliffe, 1989; Farah, McMullen, & Meyer, 1991); Michelangelo (Sartori & Job, 1988)). In addition, there is evidence that healthy participants are slower and less accurate when naming living things (Coppens & Frisinger, 2005; Gaffan & Heywood, 1993; Humphreys et al., 1988; Moore & Price, 1999). Nevertheless, there are a number of normative studies that report better performance with living things (e.g. Filliter, McMullen, & Westwood, 2005; Laws & Neve, 1999). Moreover, attempts to quantify what is meant by *visual overlap* or *structural similarity* have been problematic.

Concerning the latter, using items from the Snodgrass and Vanderwart (1980) corpus, early research defined structural similarity as the degree of *contour overlap* for subcategories of items (see Humphreys, Riddoch, & Quinlan, 1988), with contour overlap calculated by the average overlap between images, as a function of the amount of shared contour within a simple grid. Using this method, high structural similarity items were exclusively living things. More recently, Tranel, Logan, Frank and Damasio (1997) used a more sophisticated method of calculating structural similarity, based on the number of pixels falling within the maximal shape overlap for a category. This approach revealed that the greatest overlap occurred for fruits and vegetables, followed by vehicles, animals, and musical instruments, with the lowest overlap reported for tools and kitchen utensils, a finding that does not fully support the notion that living things have higher structural overlap.

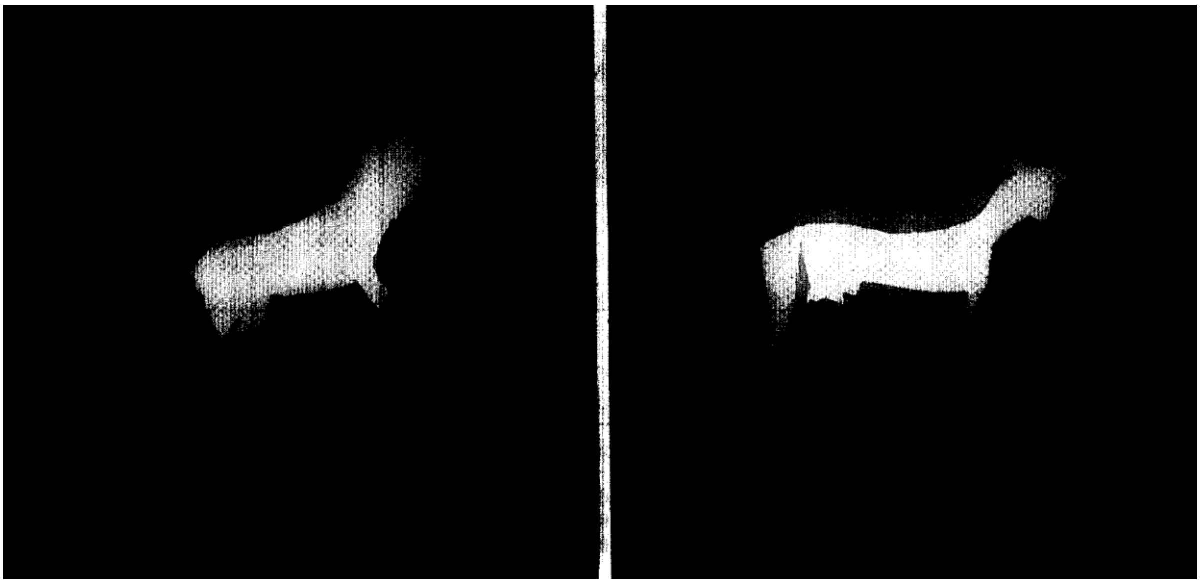


Figure 1.2 Two examples of within category maximal shape overlap outputs. The image on the left shows the shape overlap image for the region of interest of a lion, dog, and German Shepard, whilst the image on the right is that of the donkey, goat, horse, and zebra. The brightest regions show maximal overlap. Taken from Tranel et al., (1997).

Of the measures of structural similarity discussed thus far, both measures notably fail to tap internal detail. More recently, however, Laws and Gale (2002) described a measure that reflects the Euclidean overlap (EO) of images at the individual pixel level, and therefore captures both the internal and external features of each item. This measure reflects retinotopic similarity (as opposed to perceptual or conceptual similarity). The EO between two pictures is the square root of the sum of the squared differences, where the differences are calculated as the value of an individual pixel in the first picture minus its value in the second.

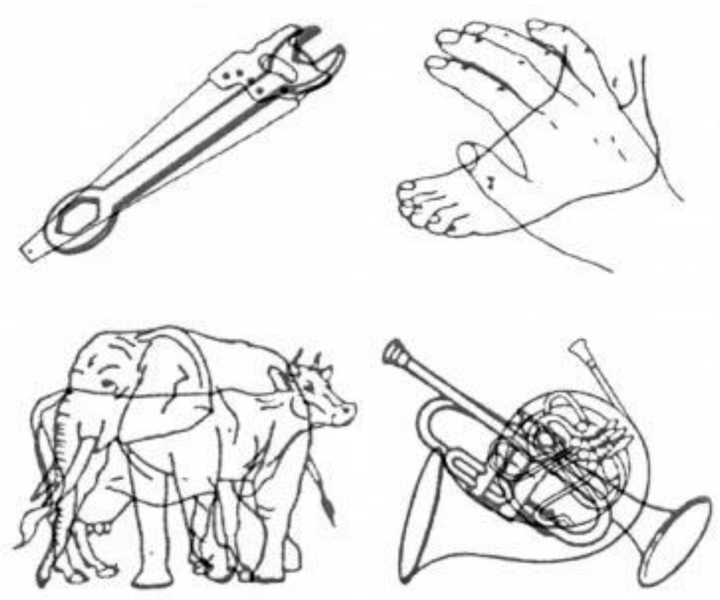


Figure 1.3 Examples showing the overlap of pairs of items from the subcategories of tools, body parts, animals, and musical instruments. Taken from Laws & Gale (2002).

Using the EO method, Laws and Gale reported greater within-category structural similarity for nonliving things. In addition, this measure also differentiated between living and nonliving things, and moreover, showed a similar pattern of within-category dissociation to that which has been observed in several behavioural studies of category-specificity (see Figure 1.4) in that body parts were found to cluster with nonliving things, whilst musical instruments clustered with living things (e.g. Warrington & Shallice, 1984). Nevertheless, the discrepancy between the findings of Laws and Gale, and those of earlier studies (Humphreys et al., 1988; Tranel et al., 1997), which suggest greater structural similarity for living things, poses problems for the VCH account.

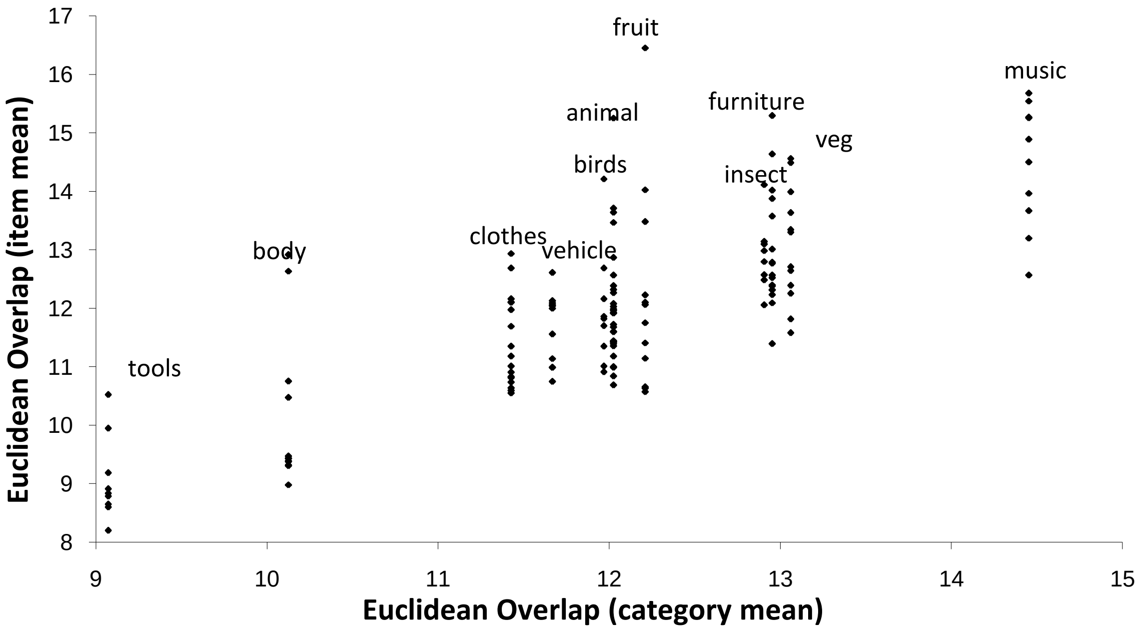


Figure 1.4 Mean EO ratings for the items and for the subcategories. Taken from Laws and Gale (2002)

1.2.5 The Pre-semantic account of Category Effects (PACE)

Despite the issues surrounding the quantification of structural similarity, the VCH account has recently been extended to provide a more comprehensive explanation of research findings. The pre-semantic account of category effects (PACE; Gerlach, Law, & Paulson, 2004, 2006) posits that structural similarity differentially effects recognition at two stages of visual processing; shape configuration and selection. Shape configuration is concerned with the binding of shape elements into shape representations, whilst selection refers to the process of matching the shape representation to competing representations in long-term visual memory. In short, it is argued that at the shape configuration stage, under normal viewing conditions, greater within-category structural similarity creates an advantage for living things as global shape may be more diagnostic of basic level identity (Gerlach, 2001; Lloyd-Jones & Luckhurst, 2002; Låg, Hveem, Ruud, & Laeng, 2006; Panis, Vangeneugden, Op de Beeck, & Wagemans, 2008; Riddoch & Humphreys, 2004; Thomas & Forde, 2006; Vannucci, Viggiano, & Argenti, 2001; Viggiano, Costantini, Vannucci, & Righi, 2004; Wagemans et al., 2008). By contrast, the recognition of nonliving things would rely more heavily on processing of local features, which is secondary to the processing of global features. At the selection stage however, greater structural similarity among living things would make it more difficult to match the shape representation with a specific stored representation. Thus, at this stage, it is likely that there would be a nonliving advantage.

An advantage of this account is that it explains how task demands might influence the emergent category effects. As noted above, it is held that under normal viewing conditions, processing at the shape configuration stage will condone an advantage for living things. Thus, the processing of nonliving things would be more susceptible to the effects of image degradation (i.e. through rapid presentation or blurring). This corresponds with findings of a living advantage when images are viewed under sub-optimal conditions (Gerlach, 2001; Låg, 2005; Laws & Neve, 1999; Lloyd-Jones & Luckhurst, 2002; Thomas & Forde, 2006; Wagemans et al., 2008). At the selection stage, the level of discrimination required may determine whether an advantage for living or nonliving things emerges. If demand on differentiation is high (and viewing conditions optimal) then the disadvantage for nonliving things at the shape configuration stage would be outweighed by the greater competition for living thing representations resulting from the high degree of structural similarity among items from this domain. This is consistent with studies reporting faster processing of nonliving things under normal viewing conditions (Humphreys et al., 1988; Moore & Price, 1999), and on difficult object decision tasks (Gerlach, 2001; Gerlach et al., 1999, 2006; Lloyd-Jones & Humphreys, 1997). Nevertheless, if task demands are low, then the living advantage would persist, as has been demonstrated by Gale, Laws, and Foley (2006), Keifer (2001), Price and Humphreys (1989), and Riddoch and Humphreys (1987a).

Neuroimaging data provides further support for this account. In accordance with the model, different brain regions are thought to be responsible for processing at the shape configuration and selection stages. As indicated by earlier research findings (Bar et al., 2001; Gerlach et al., 2006; Grill-Spector, Kushnir, Hendler, & Malach, 2000; James, Humphrey, Gati, Menon, & Goodale, 2000; Joseph &

Gathers, 2003), Gerlach (2009) argued that the anterior parts of the fusiform gyrus would be involved in image selection, whilst based on the posterior-to-anterior principle of visual processing, shape configuration should occur at more posterior regions of the fusiform gyrus, specifically the posterior parts of the inferior temporal gyri, the posterior and middle parts of the inferior temporal gyri and regions in the peristriate cortex. In accordance with PACE, it would follow that the processing of living things would lead to greater activation of the anterior parts of the fusiform gyri, whilst processing of nonliving things would be more dependent upon the inferior temporal gyri, the posterior and middle parts of the inferior temporal gyri and regions in the peristriate cortex. Consistent with this, analysis of positron emission tomography (PET) scans of 39 participants completing a difficult object decision task revealed that processing of nonliving things was associated with greater activation in posterior parts of the occipitotemporal cortex, whilst the processing of living things was more dependent upon more anterior structures. Interestingly, the study also demonstrated a lack of activation of the anterior and lateral parts of the temporal lobes, areas typically associated with semantic processing (e.g. Gitelman, Ashburner, Friston, Tyler, & Price, 2001; Mummery et al., 2000). Moreover, behavioural results revealed significantly better performance with nonliving things. Thus, this shows that category effects may emerge pre-semantically.

1.2.6 The Sensory-Functional Hypothesis

The sensory-functional model (Warrington & Shallice, 1984) suggests that the organisation of conceptual knowledge (i.e. semantic memory) is based on sensory modality rather than category, and that category specific deficits arise due to impairment of information from different modalities. More specifically, it argues that the recognition of living things is dependent upon visual or perceptual information; therefore, impaired processing of this form of information would result in a deficit for this domain. Conversely, recognition of objects from the category of nonliving things relies largely upon information relating to function therefore damage to functional information processing would result in a nonliving thing deficit. A computational variant of this account shows some support for this notion, as a system in which the ratio of visual-functional features is higher for living things than nonliving things shows impaired performance for living things when the visual component is damaged (Farah & McClelland, 1991; Small, Hart, Nguyen & Gordon, 1995). Interestingly, this account might also explain more fine-grained dissociations reported in the literature. For example, Warrington and Shallice (1984) argue that impairment in the recognition of musical instruments, metal, precious stones, and cloth observed alongside a relative impairment for living things exhibited by patient J.B.R may occur because these items require visual information for identification. Similarly, the deficit for body parts sometimes observed alongside a deficit for nonliving things (for discussion see Barbarotto, Capitani & Laiacona, 2001; Laws, Gale, Frank & Davey, 2002) could emerge because identification of these items relies on functional information. However, this model struggles to account for the reported dissociations between animals and fruit and vegetables (Caramazza & Shelton, 1998; Crutch & Warrington, 2003; Farah & Wallace, 1992; Hart et al., 1985; Hart & Gordan, 1992; Samson & Pillon, 2003). Indeed, it predicts that as living things depend on visual information, a dissociation is unlikely to occur within this category. Though it has been suggested that the recognition of fruits and vegetables may rely more heavily on a particular type of visual information, namely colour information (Warrington & McCarthy, 1987; Humphreys & Forde, 2001) the report of a patient with problems recognising colour but no deficit for fruits and vegetables poses problems for this hypothesis (Miceli, Fouch, Capasso, Shelton, Tomaiuolo, & Caramazza, 2001).

The sensory-functional account makes two further predictions. Firstly, it is argued that patients with category specific deficits will also have deficits for the modality of information upon which the impaired category depends. Early studies provide support for this prediction, as a number of patients showing a living thing deficit also showed impaired processing of visual attributes (Basso, Capitani, & Laiacona, 1988; Farah, Hammond, Mehta, & Ratcliff, 1989; Silveri & Gainotti, 1988). However, not only have these studies been criticised on methodological grounds (Caramazza & Shelton, 1998) but more recently, cases have been reported of patients who are equally impaired in the processing of visual and functional information for living things, and equally unimpaired for the processing of both kinds of information for nonliving things (Caramazza & Shelton, 1998; Laiacona et al., 1993, 1997; Lambon-Ralph et al., 1998; Laws, Evans, Hodges & McCarthy, 1995; Moss, Tyler, Durrant-Peatfield, & Bunn, 1998; Samson et al., 1998). In accordance with this prediction, the model also suggests that a disproportionate deficit for a particular modality will be accompanied by a deficit in the recognition of items from the category dependent on that modality for identification. However, this is again challenged by reports of patients with impaired visual knowledge, who fail to show an associated deficit for living things (Lambon-Ralph et al., 1998; Miceli et al., 2001).

1.2.7 The Organised Unitary Content Hypothesis

In contrast to the notion that category specific disorders are the result of damage to distinct modality specific stores of knowledge, it may be argued that dissociations between the categories of living and nonliving things are the product of damage to a unitary semantic system. Indeed, the organised unitary content hypothesis (OUCH: Caramazza, Hillis, Rapp & Romani, 1990) argues against the idea of explicit category boundaries altogether, alleging that semantic properties are not uniformly distributed but may cluster together independent of modality. It is assumed that highly correlated concepts (i.e. the conceptual features relating to object properties that co-occur) will likely be found adjacent to one another and as such, will be damaged together resulting in category specific deficits (Caramazza, Hillis, Rapp & Romani, 1990; Hillis & Caramazza, 1991; Hillis, Rapp & Caramazza, 1995; Rapp, Hillis & Caramazza, 1993). As the presence of such clusters implies that regions of the semantic system will differ in regard to the density of information, it is likely that category specific effects will only emerge when densely packed regions are damaged.

While this theory can account for those findings which show category specific effects to emerge independent of modality (e.g. Caramazza & Shelton, 1998; Laiacona et al., 1993, 1997; Lambon-Ralph et al., 1998; Moss et al., 1998; Samson et al., 1998), and also for the more fine-grained dissociations (e.g. Hart, Berndt & Caramazza, 1985; Hillis & Caramazza, 1991; Laws, Leeson & Gale, 2002b; Silveri & Gainotti, 1988; Warrington & Shallice, 1984), it fails to explain why the boundaries of categories are such as have been observed (Caramazza, 1998). Correspondingly, the account does not make any predictions as to what category effects are likely to emerge.

1.2.8 Are categories represented by distinct neural regions?

As can be seen above, though some researchers believe that category specific deficits emerge as a result of damage to a unitary system, the majority of theorists argue that the living-nonliving impairments indicate a categorical organisation of lexical-semantic processes (e.g. Caramazza & Mahon, 2003; Caramazza & Shelton, 1998; Collins & Quillian, 1969; Laiacona et al., 1997; Mahon & Caramazza, 2003; Pietrini et al., 1988; Sartori & Job, 1988; Warrington et al., 1981). Indeed, Pietrini et al., (1988) argued that semantic domains are pivotal to the organisation of the mental lexicon, and moreover, that these are represented by distinct areas of the neural cortex. However, using imaging techniques to explore this idea in two HSE patients, Pietrini and colleagues were unable to demonstrate evidence of a neuronal basis for the extant living thing deficit. A recent review of the neuroanatomical damage associated with category deficits was, however, able to identify certain regions associated with the processing of living and nonliving things. Specifically, Gainotti (2000) found that living thing impairments are typically associated with bilateral damage to the inferior temporal lobes and medial structures (hippocampus, amygdala, and parahippocampal gyri) because of HSE, head trauma, or semantic dementia. Conversely, deficits for nonliving things are more strongly correlated with damage to the left middle cerebral artery, which typically occurs following a stroke. Though these findings offer some support for the notion that category specific deficits are a product of damage to a categorically organised lexical-semantic system, there are however, numerous reports of category specific deficits in a variety of other pathologies including AD, Lewy Body Dementia, and Schizophrenia, in which the involvement of the temporal lobes may be less apparent than in cases of HSE, for example. Moreover, in disorders such as AD, damage is typically diffuse, and widespread (Henderson & Finch, 1989; Pearson et al., 1985; Rogers & Morrison, 1985). As such, it is somewhat difficult to reconcile with the notion that category deficits emerge as a result of damage to a substrate of a specific domain, as it is unlikely that damage to either living or nonliving things would be exclusive.

Concerning the incidence of category specific deficits in AD, one of the earliest reports comes from Silveri and co-workers (1991). They reasoned that as damage to the temporolimbic regions is present in AD as well as HSE, it might be that persons with AD perform in a similar way to those with HSE on lexical-semantic tasks, thus demonstrating a category specific deficit. Their study explored this hypothesis by comparing the performance of 15 AD patients to that of 10 age- and education-matched controls on a confrontation-naming task. Consistent with their predictions, Silveri and colleagues found not only that the overall naming ability of AD patients was impaired relative to that of controls, but that this impairment was considerably marked for living things and sustained across mild and moderate cases of AD.

Whilst the study conducted by Silveri and co-workers has prompted research into category specific deficits in AD, it has received some criticism on methodological grounds. Specifically, the validity of this finding has been called into question, as the researchers failed to control for nuisance variables (see section 1.2.3), which have subsequently been shown to co-vary significantly with semantic domain (Funnell & Sheridan, 1992; Stewart, Parkin, and Hunkin, 1992). Indeed, a later study of AD patients by Tippett, Grossman, and Farah (1996) replicated the findings of Silveri and collaborators using their original stimulus set, but was unable to confirm this pattern using a newer set of pictures, more tightly matched for familiarity, lexical frequency and visual complexity.

Despite the findings of Tippett et al., (1996) many studies have since investigated category specific naming performance in AD using more rigorously controlled sets of pictorial stimuli. Whilst a small number have failed to report a category effect when employing stringent control of extraneous variables (e.g. Tippett et al., 2007), generally, the emergent findings are relatively consistent with those obtained from patients with HSE and other forms of neurological damage in that the majority report living thing impairments (e.g. Gainotti & Silveri, 1996; Grossman, Robinson, Biassou, White-Devine, & D'Esposito, 1998; Mauri, Daum, Sartori, Riesch & Birbaumer, 1994). Nevertheless, a small minority have reported the reverse dissociation, specifically a deficit for nonliving things (Gonnerman, Anderson, Devlin, Kempler and Seidenberg, 1997; Laws, Gale and Leeson, 2003; Laws, Gale, Leeson and Crawford, 2005; Tippett et al., 1996).

1.3 WHAT IS ALZHEIMER'S DEMENTIA (AD)?

Alzheimer's dementia (AD) is a degenerative disorder, which accounts for approximately half (50-60%) of all dementia cases (Cummings & Benson, 1992). Though the underlying causes of this disease are not well understood, the likelihood of disease onset is known to increase with age, with prevalence increasing from less than one percent in individuals between the ages of 60-64years, to 24-33 percent in persons over the age of 85 years (Ferri, Prince, Brayne et al., 2005). It is characterised by the emergence of senile plaques and neurofibrillary tangles, primarily in the cerebral cortex, though pathological changes are present to a lesser extent in the subcortex. In addition, it is typified by neuron loss, cerebral atrophy, and neurochemical changes.

Concerning the clinical features of AD, the earliest symptom is commonly memory impairment, initially short-term, but encroaching on long-term memory also. Deficits in abstract thinking, and judgement are also common, with disturbances of higher cortical functions such as aphasia (disorder of language), apraxia (intact comprehension of motor function with inability to carry out motor tasks) and agnosia (failure to identify or recognise objects despite intact sensory function) often present. In addition to the cognitive impairments typical of AD, a number of neuropsychiatric features may also be observed, including apathy, depression, personality change, delusions, hallucinations, and challenging behaviours. Ultimately, AD is a progressive disorder that leads to mutism, and unresponsiveness, with most patients being bed ridden and showing marked physical deterioration. Death, as is the case for all dementias, often occurs because of infection and consequently organ failure.

Of the cognitive impairments noted to occur in AD, the marked impairment of semantic memory processing typically associated with the disease is of particular interest in the context of this review

(Bayles & Tomoeda, 1983; Bayles, Tomoeda, & Trosset, 1990; Chertkow & Bub, 1990; Done & Gale, 1997; Hodges, Salmon, & Butters, 1991; Martin & Fedio, 1983; Salmon, Butters, & Chan, 1999). It is recognised that semantic memory impairment emerges early in the course of AD, occurring in as many as 50% of mild AD cases (Hodges, Salmon, & Butters, 1992), as well as in pre-AD neuropathology (i.e. cases of mild cognitive impairment: Ahmed, Arnold, Thompson, Graham, & Hodges, 2008; Dudas, Clague, Thompson, Graham, & Hodges, 2005; Joubert, Felician, Barbeau, Didic, Poncet, & Ceccaldi, 2008; Vogel, Gade, Stokholm, & Waldemar, 2005).

1.3.1 Semantic memory in AD: an impairment of access or loss of conceptual knowledge?

Semantic impairments in AD have been described across a range of tasks, including: picture naming (Silveri, Daniele, Giustolisi, & Gainotti, 1991); object decision (Daum, Riesch, Sartori & Birbaumer, 1996); probe questioning (Done & Gale, 1997); semantic association (Mauri, Daum, Sartori, Riesch & Birbaumer, 1994); word to picture matching (Garrard, Lambon Ralph, Watson, Powis, Patterson, & Hodges, 2001); and naming to definition (Mondini, Borgo, Cotticelli, & Bisiacchi, 2006). However, performance on semantic tasks typically involves other cognitive processes (e.g. executive function, attention, language, visual-perceptual processes). Thus, impairments may result from degradation of a particular sensory modality of input necessary for accessing item knowledge, or from actual loss of semantic information (Ratcliffe & Newcombe, 1982; Shallice, 1988a). For example, in cases of associative or integrative visual agnosia, some patients have been found only to exhibit object recognition deficits for the visual domain of processing, with intact verbal semantic processes (Riddoch, Humphreys, Coltheart, & Funnell, 1988). In addition, there are also cases in which the patient shows selective access difficulties for spoken (Warrington & McCarthy, 1983) or written language (Warrington & Shallice, 1979). Conversely, several studies have documented cases of visual agnosia in which the deficits reflect an actual breakdown of semantic knowledge (Sartori & Job, 1988; Warrington, 1975; Warrington & Shallice, 1984).

A number of researchers have argued that the poor performance shown by AD patients on semantic tasks is the result of impaired access to semantic memory (for review, Bayles, Tomoeda, Kasznaik, & Trosset, 1991; Nebes, 1989), though the majority now attribute this to degradation of semantic knowledge (Chan, Butters, Paulson, Salmon, Swenson, & Maloney, 1993; Chan, Salmon, Butters, & Johnson, 1995; Chertkow & Bub, 1990; Hodges & Patterson, 1995; Hodges, Salmon, & Butters, 1992; Martin, 1992; Martin & Fedio, 1983) based on the criteria outlined by Warrington and Shallice (Shallice, 1988a, 1988b; Warrington & Shallice, 1984). Specifically, Warrington and Shallice proposed that for poor performance on semantic tests to be defined as evidence of a 'semantic storage disorder' there must be; (i) loss of subordinate knowledge with preservation of superordinate knowledge, (ii) consistent performance across tasks within a sensory modality, and across testing sessions, (iii) loss of semantic priming effects, and (iv) greater loss of information about low frequency items. In accordance with the criteria outlined by Warrington and Shallice, several studies have found that AD patients exhibit strong item-to-item consistency across different tasks (Chertkow & Bub, 1990; Hodges, Salmon, & Butters, 1992; Huff, Corkin, & Growden, 1986; Hodges & Patterson, 1995; Rogers, Patterson, Ivanoiu & Hodges, 2006), particularly on tasks of naming ability, attribute knowledge, (Harley & Grant, 2004), and their ability to provide definitions (Lambon Ralph, Patterson & Hodges, 1997). A number of studies have also shown that on tests of picture sorting and generation of verbal definitions of items, AD participants are markedly impaired in their ability to generate exemplars from lower order categories, but showed preserved superordinate knowledge (Chertkow & Bub, 1990; Hodges, Salmon, & Butters, 1992). In addition, Hodges and colleagues (Hodges, Salmon, & Butters, 1992) noted that the deficits exhibited by AD patients were related to item frequency, with the naming of less familiar items being significantly more impaired than that of familiar items.

Further evidence that AD characteristically involves semantic memory impairment may be found in relation to the types of errors made on tasks of picture naming (Barker & Lawson, 1968; Hart, 1988; Hodges, Salmon, & Butters, 1991; Kirshner, Webb, & Kelly, 1984). In comparison to healthy controls and patients with other forms of dementia, AD patients are typically found to exhibit a higher numbers of semantic confusion errors, namely superordinate (e.g. answering 'BIRD' for 'ROBIN') and within category associative errors (e.g. answering 'SHEEP' for 'GOAT'). By contrast, errors at pre-semantic (visual) or post-semantic (phonological) stages of object recognition occurring rarely, and being limited to more advanced cases (Barker & Lawson, 1968; Hodges, Salmon, & Butters, 1991; Kirshner, Webb, & Kelly, 1984). Thus, it is thought that semantic impairments underpin the anomia commonly reported in AD patients (Chertkow & Bub, 1990; Daum, Riesch, Sartori & Birbaumer, 1996; Hodges, Salmon, & Butters, 1992; Mauri, Daum, Sartori, Riesch & Birbaumer, 1994).

1.4 *ACCOUNTS OF SEMANTIC MEMORY SPECIFICALLY RELATING TO CATEGORY-SPECIFICITY IN AD*

Evidence of category specific disorders in AD patients is potentially problematic for many of the theories discussed thus far. With the exception of the artefactual and OUCH accounts, all theories of category-specificity rely on the idea that relatively localized brain damage results in damage to specific semantic mechanisms. Though this is typically the case in HSE and some stroke patients, AD commonly results in diffuse damage to most areas of the association cortex (Henderson & Finch, 1989; Pearson et al., 1985; Rogers & Morrison, 1985). Thus, theories which infer that category specific deficits are the result of localized damage cannot be extended to account for deficits in AD. There are however, two theories which, in keeping with the OUCH account, propose that a unitary semantic system may be organized via correlated networks.

1.4.1 Gonnerman, Andersen, Devlin, Kempler, & Seidenberg (1997)

The earliest correlated networks account (Gonnerman, Andersen, Devlin, Kempler & Seidenberg, 1997) attempts to account for category specific deficits in patients with either localized or widespread damage by adapting a computational model outlined by Farah and McClelland (1991). In keeping with the sensory-functional approach, this account suggests living things are more readily recognized on the basis of their perceptual attributes, and nonliving things on the basis of functional attributes, though goes further to suggest a ratio for the relative importance of perceptual/functional features to the recognition of living/nonliving things (7.7:1 & 1.4:1 respectively). On the basis of this, Farah and McClelland formed a connectionist model, which generated the correct semantic pattern when presented with a picture or word. They noted that lesions to the perceptual features primarily impaired recognition of living things, while damage to functional features impaired nonliving things. Thus this model is useful in accounting for deficits resulting from focal brain damage. Nevertheless, this account alone cannot account for the emergence of category specific deficits in patients with widespread, patchy damage. To explain this, Gonnerman and colleagues introduced two factors; distinguishing features which permit discrimination between members of a category, and intercorrelations between semantic features. The former is described as being some feature that occurs almost exclusively for a particular item within a category, and is used to discriminate that item from others. Crucially, the distinguishing features tend to be the functional properties of nonliving things and the perceptual properties of living things. In addition, it is argued that the nonliving thing category has a higher number of distinguishing features than that of living things. By contrast, intercorrelated features are more prominent in the category of living than nonliving things. A feature pair is defined as being intercorrelated if they are activated simultaneously for many words in the lexicon. Thus, HAS- A-BEAK and HAS-FEATHERS can be seen as intercorrelated as they are often activated jointly.

Based on this account, it is assumed that low level lesioning will have little impact upon the recognition of living things because the high level of connectivity between features can compensate for the removal of some connections, thus providing collateral support. However, as damage accrues, a ‘critical point’ will be reached at which time the collateral support will no longer be able to sufficiently compensate for the lost connections, preventing the activity of those features in the intercorrelations reaching the activation threshold. At this point, catastrophic representation loss will occur because the large number of intercorrelations between living thing items would mean that the recognition of items within this category would be greatly impaired. By contrast, it is thought that low level lesioning might severely affect the recognition of nonliving things as the low number of intercorrelations means that small amounts of random damage can isolate distinguishing features, making it impossible to discriminate the effected nonliving things from other members of the category. Thus, damage to the intercorrelation between a particular feature and the item to which that feature is unique might make it impossible to recognize that item. However, as this feature is unique the recognition of other items in the category will be spared. In this way, though increases in the level of brain damage will cause the loss of more items, contrary to the effects of damage to intercorrelations, it will not cause the impairment of whole categories. Therefore, the model predicts that in patients with severe brain damage, processing of nonliving things will be spared relative to living things.

Computational networks have shown patterns of impairment that correspond with the predictions of the above account. Devlin, Gonnerman, Andersen and Seidenberg (1998) simulated the effects of lesioning networks of interconnected semantic units that were trained to represent the perceptual and functional features of objects. They noted that whilst an advantage for living things was observed when artificial lesioning (i.e. the removal of only a small number of connections) was mild, a nonliving advantage was observed when damage was profuse. A similar pattern of impairment has also been reported in a group of AD patients (Gonnerman et al., 1997). However, the deficits noted in this study are inconsistent with those observed in the majority of studies that employ the use of large cohorts of AD patients (Garrard, Lambon Ralph, Watson, Powis, Patterson & Hodges, 1998; Montanes et al., 1995; Silveri et al., 1991; Whatmough et al., 2003; Zannino et al., 2002). Moreover, a number of researchers have suggested that the findings of Gonnerman et al. (1997) are the result of ranking patients according to their performance on one category only (Zannino et al., 2002). In keeping with this, when performance has been ranked according to overall naming impairment or MMSE scores, living thing knowledge was impaired relative to that of nonliving things at all levels of impairment (Garrard, et al., 1998).

1.4.2 Moss, Tyler, and colleagues

The assumption that the distinctiveness and correlatedness of properties play a major role in determining conceptual structure also underlies another account of category-specificity outlined by Durrant-Peatfield, Tyler, and colleagues (Durrant-Peatfield, Tyler, Moss, & Levy, 1997). However, their account differs from that of Gonnerman and co-workers on two important aspects; firstly, they place greater emphasis on the role of functional information as a determinant of conceptual structure (Tyler, Moss, Durrant-Peatfield & Levy, 2000); and secondly, it is maintained that functional information is more resistant to brain damage than any other form of information (Tyler & Moss, 1997; Moss, Tyler, Patterson & Hodges, 1995).

Contrary to Gonnerman and co-workers' hypothesis that functional properties are more important for the recognition of nonliving things than living things, Moss, Tyler and colleagues argue that functional semantic information is salient for both nonliving and living things, though there are differences in the type of functional information salient to each category, and in the distinctiveness and correlatedness of the perceptual information to which information about function is inextricably linked. Specifically, the functional information salient to the recognition of nonliving things relates to the use of that item (e.g. scissors are used for cutting). It is thought that nonliving items tend to have a unique function (Tyler et al., 2000) and that the physical form of an object is highly diagnostic of this function (Moss, Tyler & Jennings, 1997; De Renzi & Lucchelli, 1994; Wierzbiecka, 1985). In this way, items from the category of nonliving things have distinctive perceptual features that are associated with distinctive functional information. By contrast, the distinctive perceptual features of living things (e.g. HAS-STRIPES, HAS-SPOTS) are not usually associated with a specific function[1]. It is reasoned that the type of functional information salient for the recognition of living things concerns biological functions (e.g. flying, seeing etc.). As these functions are usually characteristic of many members of a category, it follows that the perceptual features associated with these biological

[1] Nevertheless, the distinctive perceptual features in themselves may arguably be seen as functional (i.e. HAS-STRIPES would be a product of natural adaptation, to aid camouflage and therefore avoid detection by predators/prey).

functions are also shared by many other living things (e.g. HAS-WINGS, HAS-EYES respectively). In this way, shared perceptual features become associated with shared biological functions.

The differences that are said to exist between the degree and type of correlations associated with items from the living and nonliving categories, as well as the disproportionate impairment of perceptual information relative to functional information has important implications for the pattern of loss that might occur as a product of neurological damage. Firstly, it is predicted that as the distinctive properties of living things are weakly correlated to functional features they will be vulnerable to loss even when damage to the brain is minor. Thus, patients with mild AD for example, may display problems naming living things in word-picture matching tasks. However, the same group of patients are unlikely to show a deficit for living things on tasks where distinctive information is not necessary (e.g. categorisation tasks), as the correlations between shared features will preserve performance (Moss et al., 1998). In contrast to this, minor damage will have little effect on the nonliving category, as the distinctive properties are highly correlated and therefore more resilient to damage.

The effect of severe damage is however, expected to produce the opposite pattern of impairment. It is argued that deficits for nonliving things will arise because of high levels of neurological impairment. However, due to the robustness of the correlations between shared features, the recognition of living things will be relatively spared. Furthermore, the type of errors that do occur for living things will differ to those of nonliving things. Because of the lack of correlations between the shared and distinctive features of nonliving things, errors may occur across subcategories. However, the presence of correlations between shared features would largely prevent these kinds of errors in the recognition of living things.

As with Gonnerman and co-workers' theory, there is support from computational studies for Moss, Tyler, and colleagues' account. Durrant-Peatfield et al. (1997) demonstrated that when high numbers of lesions were simulated in a model of the semantic system, based on the above hypotheses, a small advantage for living things was reported. This was attributed to the ability of those remaining correlated features to support the identification of core sets of objects. Patient data also reveals evidence that supports this account. Longitudinal studies of AD patients ES and AA show a significant deficit for nonliving things in the later stages of the disease, in contrast to a slight deficit for living things (on some tasks) in the early stages (Moss & Tyler, 1997; Moss, Tyler & Devlin, 1999; Moss & Tyler, 2000). Importantly, neither of the patients reported in these studies exhibited a significantly greater impairment for functional or perceptual information, thus supporting the notion that these features are part of a unitary system rather than being independently represented by different regions of the brain. However, recent research exploring specific predictions as to the types of features that the model predicts will be impaired in AD has failed to find support for this account. Duarte, Marquié, Marquié, Terrier, and Ousset, (2009), explored the hypotheses that (i) the distinctive perceptual features of living things should be impaired in early AD relative to those of nonliving things, and the shared features of both living and nonliving things, and (ii) shared features of living things should be best preserved in moderate AD. Contrary to expectation, they found that all distinctive features were lost in early AD, irrespective of domain, and that shared features remained relatively preserved across domain in moderate AD. Thus, though this study demonstrates that distinctive and shared features may be dissociated, impairment of a particular class of features is not necessarily associated with impairment with living or nonliving things.

1.5 A 'NORMAL' NAMING PROFILE

The theories of semantic memory discussed above, suggest that conceptual knowledge is organised in a way that might explain the emergence of category specific deficits in neurologically impaired individuals. However, little attention has been given to what happens in neurologically intact individuals. It is only relatively recently, that researchers have begun to explore category-specificity from a normative viewpoint, and indeed, consider patient performance in relation to that of healthy, matched controls. Nevertheless, the outcome of such studies may have important implications for theories of semantic memory, and for the way in which investigations of category specific deficits in neurologically impaired patients may be interpreted. It is problematic therefore, that the findings of such studies are somewhat inconsistent. Indeed, whilst the majority of studies have reported that healthy controls are faster and more accurate with living things (Brousseau & Buchanan, 2004; Filliter, McMullen & Westwood, 2005; Laws 1999, 2000, 2002, 2003; Laws, Leeson and Gale, 2002a; Laws & Neve 1999; McKenna & Parry, 1994), others have reported an advantage for nonliving things (Gaffan & Heywood, 1993; Humphreys, Riddoch, & Quinlan, 1988; Laws & Gale 2002).

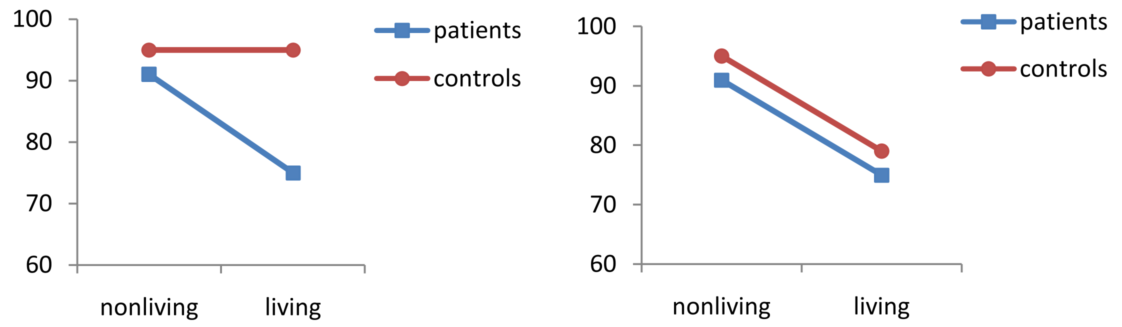
1.5.1 Inconsistencies in the normal naming profile: a product of intrinsic item variables?

There are several possible explanation for the discrepancies reported in studies of normal naming performance, that are concerned with the methods used to conduct this research. For example, a number of researchers have argued that if, as suggested, the recognition of living things requires greater cognitive effort than that of nonliving things, (Funnell & Sheridan, 1992; Moreno-Martinez, Tallón-Barranco & Frank-Garcia, 2007; Stewart, Parkin & Hunkin, 1992; Tippett, Grossman, & Farah, 1996) failure to match across category on potentially confounding variables may produce greater naming latencies and reduced accuracy for living things in healthy controls. This may therefore explain why early studies, which did not properly control for potentially confounding variables such as concept familiarity and visual complexity, report a disadvantage in the speed (Humphreys, Riddoch & Quinlan, 1988; Lloyd-Jones & Humphreys, 1997) and accuracy (Gaffan & Heywood, 1993) with which living things are named by healthy controls. Moreover, this is further corroborated by evidence from a number of recent studies, which report the opposite trend when these variables are properly controlled (Brousseau & Buchanan, 2004; Filliter, McMullen & Westwood, 2005; Gerlach, 2001; Låg, 2005; Laws, 2000; Laws & Neve, 1999; Lloyd-Jones & Luckhurst, 2002; McKenna & Parry, 1994; though see also Coppens & Frisinger, 2005), thus supporting the notion that when intrinsic item variables are not matched, a living thing disadvantage may be the normal tendency.

1.5.2 Inconsistencies in the normal naming profile: the problem with ceiling effects

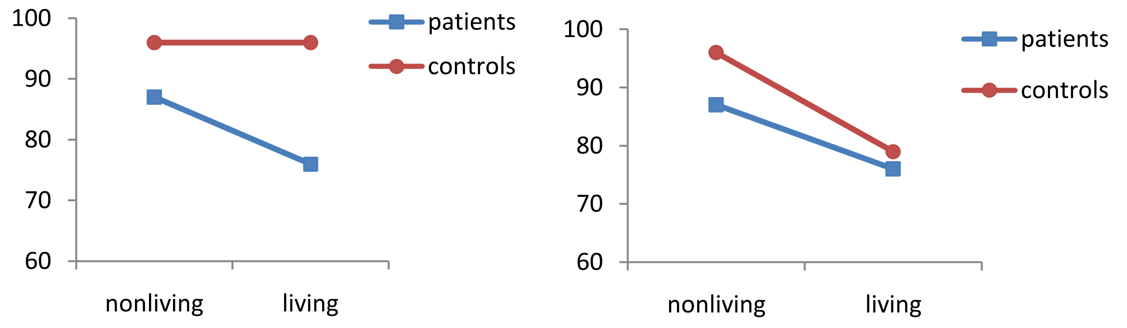
A second methodological issue, which may account for the inconsistencies reported in the normal naming profile, relates to the stimuli typically used to explore naming in healthy participants. Indeed, the majority of studies in this area (approximately 90%) have employed simple line drawings of familiar everyday objects (e.g. such as those featured in the corpus developed by Snodgrass and Vanderwart, 1980). As such, these items are readily identifiable by healthy controls, resulting in at or near ceiling performance (Laws, 2005). Thus, it is often the case that data obtained from neurologically impaired patients is compared to that of controls performing at ceiling (e.g. Living/non-living: Garrard et al., 2001 [90.5/93.3%]; Gonnerman et al., 1997 [97/97.2%]; Mauri et al., 1994 [98/98%]; Montanes, Goldblum & Boller, 1995 [96/97%]; Silveri et al., 1991 [99.8/99.8%]; Zannino et al., 2002 [98/98.3%]). As this may mask any category effects exhibited by controls, this may distort the interpretation of patient data, in terms of both the degree and type of impairment documented (Fung, Chertkow, Murtha, Whatmough, Peloquin et al., 2001; Laws, Gale, Leeson & Crawford, 2005). For example, an apparent deficit for living things in patients could simply be an exaggeration of the normal trend if controls also find it more difficult to name living things. However if controls perform at ceiling, the normal trend would be hidden, and a potentially spurious category specific impairment in patients would be reported (see figure 1.5). Similarly, patients may appear to show a living thing deficit when compared with controls at ceiling. However if controls perform better on non-living things, whilst their performance on living things is comparable to that of patients, patients are actually displaying a nonliving thing deficit (see figure 1.6).

Figure 1.5 Example of a false positive (type 1 error) when referencing patients to controls performing at ceiling.



Note. the left figure depicts a living thing error in reference to controls at ceiling, whilst the right figure shows that when reference to controls performing below ceiling who also show better performance with nonliving things, the deficit for living things disappears.

Figure 1.6. Example of a paradoxical category specific deficit when referencing patients to controls performing at ceiling.



Note. The left figure again shows a living thing deficit in relation to controls at ceiling. However the right figure shows how if the normal trend is for healthy controls to perform better with nonliving things, then the patient data may actually depict a deficit for nonliving things.

With regard to spurious deficits, this may in part account for the higher incidence of living thing deficits reported in the category specific literature, as findings from a recent meta-analysis suggest (Laws et al., 2007a). As noted earlier, the findings of this investigation revealed that within the AD population, whilst the majority of studies report a living thing deficit, the effect sizes for living and nonliving things were comparable, demonstrating evidence of both living and nonliving deficits in AD when performance was referenced to that of healthy controls.

Ceiling level performance is also evident in normative studies of category-specificity (e.g. Living/non-living: Låg, 2005 [expt. 2: 96.45%/95.45%]; Laws, 2000 [96.99%/95.57%]; Laws et al., 2003 [set 1: 95.6%/96.6%]; Laws & Hunter 2006 [expt.1:96.6%/94.25%; expt.2: 97.6%/94.35%]). Thus, in an attempt to avoid this, a number of researchers have introduced time constraints, in the form of speeded presentation paradigms (Låg, 2005; Laws, 2000; Laws & Neve, 1999), or speeded naming paradigms (Brousseau & Buchanan, 2004; Tippett et al., 1996). Though these have the desired effect of preventing performance reaching ceiling level, researchers have argued that changing the experimental paradigm in this way might in itself, influence findings (Laws & Neve, 1999). In accordance with the visual crowdedness hypothesis for example, Laws and Neve argued that the use of rapidly presented stimuli might disadvantage the recognition of low structural similarity items (typically taken to be nonliving things), as such viewing conditions creates an advantage for the processing of low spatial frequency components, or global features (Kitterle & Christman, 1991; Sergent, 1983), which would aid the recognition of structurally similar living things. Thus, the living advantage reported in studies that have used degraded viewing conditions (Brousseau & Buchanan, 2004; Låg, 2005; Laws, 2000; Laws & Neve, 1999; Tippett et al., 1996) might in fact be an artefact of task demands. Several studies provide support for this notion (Gerlach, 2001; Låg, 2005; Laws & Neve, 1999), however there are some that report contradictory findings (Laws, & Hunter, 2006; Filiter, McMullen, & Westwood, 2005), showing that the living thing advantage persists even under normal viewing conditions.

Given the problems inherent to the use of degraded viewing conditions, researchers have explored other means of preventing ceiling effects in healthy controls. Perhaps the simplest method has been to use low frequency items, as a means to increase task difficulty while keeping items matched for important nuisance variables. Several studies have employed this method in normative and neurological research (Coppens & Frisinger, 2005; Fung et al., 2001; Garrard et al., 2001; Laws et al., 2005; Tippett et al., 2007; Whatmough et al., 2003). Using this approach, Coppens and Frisinger (2005) reported an advantage for nonliving things in healthy elderly participants, whilst no category effects were exhibited by a younger sample. This therefore lends support to the notion that previous reports of an advantage for living things may be attributed to specific demands of the task.

Another way in which researchers have attempted to control for the effects of ceiling performance is with statistical techniques. Laws and colleagues (Moreno-Martínez and Laws 2007, 2008; Gale, Irvine, Laws & Ferrisey, 2009), proposed the use of bootstrap statistical methods (Delucchi & Bostrom, 2004), which require far fewer assumptions about the data distribution than standard parametric tests, and are therefore better suited to use with data sets that are heavily skewed, have unequal variance across groups, and/or multiple zero errors, such as that obtained when controls are performing at ceiling. Using this method, a relevant test statistic (e.g. t, F, etc.) is computed for n permutations of the original data (n bootstrap samples). This can be performed with replacement, meaning that a data point goes back into the sampling pool with the potential for this to be redrawn numerous times. After a number of permutations (e.g. 1000), a more normal distribution of test statistics emerges. The value of the original test statistic may then be compared to the new distribution, and declared significant at, for example, the 0.05 level, if it is among the most extreme 5% of cases.

The bootstrapping technique has now been applied in a number of studies. Perhaps the most illustrative example of how this may influence findings was provided by Moreno-Martínez and Laws (2007). They compared naming across three conditions: (i) without covarying any variables, (ii) covarying the influence of nuisance variables, and (iii) covarying healthy control performance using bootstrap ANCOVAs. Findings revealed that while a significant effect of category emerged in conditions (i) and (ii), this disappeared when control performance was covaried. Thus, the category effect found in AD patients was no greater than that which would be predicted based on the performance of healthy controls. This finding has since been replicated across several semantic tasks (picture naming, naming to description, and word-to-picture matching), after using 1000 bootstrap ANCOVAs in which control performance was entered as a covariate (Moreno-Martínez & Laws, 2008). Nevertheless, using bootstrap techniques to conduct a hierarchical regression analysis of the factors influencing AD patient performance Gale et al, (2009) demonstrated that category was found to significantly predict a small amount of the variance in patient naming (3%) independent of the effects of nuisance variables (which accounted for 39% of the variance in patient naming) and control naming (which accounted for 29% of the variance in patient naming). Taken together, these findings suggest that the emergent category effect documented in AD patients may simply be an exaggeration of the normal naming profile, differing quantitatively, but not qualitatively from that of controls.

1.5.3 What are the implications of a 'normal' category effect?

The finding of a normal category effect, whether for living or nonliving things, has important implications for theories of semantic memory. Current theories of category-specificity are based on trends in neurological performance, and make few predictions about the normal profile. For example, the sensory-functional account (Warrington & McCarthy, 1983), makes no explicit predictions as to whether healthy individuals would show a living or nonliving advantage. In addition, the connectionist accounts (Durrant-Peatfield et al., 1997; Gonnerman et al., 1997; Tyler & Moss, 1997; Moss, Tyler, Patterson & Hodges, 1995), do not allude to a normal pattern of performance, though in this instance it may be possible to predict healthy naming performance based on the way in which disease severity influences AD patient performance; thus, neurologically intact individuals may do better with the category that would be preserved in AD patients, which may be living or nonliving depending on the approach. Similarly, although the domain-specific accounts do not predict normal performance, it may be argued that evidence of a normal advantage for living things might be quite plausible according to evolutionary explanations (Caramazza & Mahon, 2003; Caramazza & Shelton, 1998). Indeed, if as suggested, humans have developed specialised neural mechanisms for the processing of evolutionarily salient items (e.g. animals, plants, tools) then we would expect such systems to confer a normal advantage for the recognition of these items (Laws, 2000). Nevertheless, it is difficult to reconcile evidence of a normal nonliving advantage with this account as given the ever-changing physical appearance of man-made items it is unlikely that we would have developed systems for the processing of these items (Gale, Laws, Frank, & Leeson, 2003; Laws & Neve, 1999; Turnbull & Laws, 2000). Thus, an advantage for nonliving things may be better accounted for in the context of the artefactual account, visual crowdedness hypothesis or the pre-semantic account of category-effects.

The extent to which existent models of category-specificity may account for the emergence of a normal category effect is somewhat limited, and highlights the need for further research to determine the nature of the category advantage, specifically, is the normal pattern of performance an advantage for living or nonliving things? This has important implications also for studies of neurological performance; are the category specific deficits exhibited by neurologically impaired patients simply an exaggeration of the normal trend? Given the problems identified in the study of healthy control performance, it is necessary that future research is attentive to the potentially confounding effects of certain methodological factors, thus taking into consideration the influence of nuisance variables, and ceiling effects when interpreting findings.

Chapter 2: The Role of Surface Information in Object Recognition and the Implications for Category Specific Research

2.1 INTRODUCTION

Visual object recognition is an area that has received considerable attention within cognitive psychology as one of the most important functions of the brain. Generally, object recognition is viewed as the result of three fundamental processes; (i) the encoding of visual information to form temporary object representations, (ii) the matching of temporary representations to stored representations (structural descriptions) in visual long-term memory, and (iii) the use of stored representations to gain access to semantic information about an object. However, there is much disagreement as to what information is necessary to inform each stage of the object recognition process. Indeed, researchers recognise that multiple features of an object such as its shape, texture, and colour, may all be extracted from the visual input to potentially facilitate object recognition (Regan, 2000). Nevertheless, accounts of object recognition differ as to the importance ascribed to surface details at later stages of the object recognition process, dependent upon whether they adopt an edge-based (e.g. Biederman, 1987; Marr, 1982; Marr & Nishihara, 1978) or edge-plus-surface based approach (e.g. Gibson, 1969; Tanaka, Weiskopf & Williams, 2001; Tarr & Bülthoff, 1998). This review outlines a number of edge-based and edge-plus-surface accounts of object recognition, and considers them in relation to empirical research findings. Subsequently, the implications of current views on object recognition for the study of semantic memory, specifically through category specific research, will be discussed.

2.2 EDGE-BASED ACCOUNTS OF OBJECT RECOGNITION

Theories of object recognition can be differentiated as edge-based accounts; those that suggest that the geometric aspects of a representation are necessary for object recognition, and that surface based information provides a less reliable secondary route (e.g. Biederman, 1987; Marr, 1982; Marr & Nishihara, 1978) and edge-plus-surface accounts; those which suggest that surface details such as colour and texture are also necessary for the formation of object representations (e.g. Gibson, 1969; Tanaka et al., 2001; Tarr et al., 1998). Though edge-based accounts emphasise the importance of shape information, they typically suggest a role of surface information in early recognition processes. A good example of this is Biederman’s (1987) recognition by components theory, though other models (Bergevin & Levine, 1993; Brooks, 1981; Grimson, 1989; Hummel & Biederman, 1992; Huttenlocher & Ullman, 1990; Lowe, 1987; Stark, Eggert & Bowyer, 1988) make similar assumptions. According to this account, surface characteristics such as colour, luminance, and texture are essential for edge extraction, an early stage that provides a line drawing description of the visual object. This edge based representation is further broken down into its component parts, or ‘geons’; simple, volumetric primitives (e.g. blocks, cones, cylinders etc.) which are used to form a viewpoint-independent representation of the object that can be matched to the stored object representation. In this way, surface detail is of little importance to the object recognition process.

Biederman’s (1987) account is arguably an extension of an earlier computational model of object recognition (Marr, 1982; Marr & Nishihara, 1978). According to Marr (1982), the primary aim of vision is to reconstruct the 3D scene via the formation of a hierarchically organised series of ever more detailed object representations. The most basic representation, the primal sketch, provides a two-dimensional description of the organisation of light intensity changes in the object and of the geometrical distribution of edges and contours, the extraction of which is facilitated by surface information. This is then transformed into a 2 ½-D sketch that specifies the depth and orientation details of the surfaces of the object, using information from shading, texture, shape, motion, and binocular disparity. Though detailed, the 2 ½-D sketch is viewpoint-dependent and as such the representation formed will vary considerably across different viewing angles, making it difficult to match this temporary description to the stored representation (Marr & Nishihara, 1978). As such, the model posits that a 3-D, viewpoint-independent representation, is formed from the 2 ½-D sketch, and that it is this which is matched to stored representations. This comprises of hierarchically organised primitive cylindrical units, organised around a central axis. In this way, shape information again permits object recognition.

2.2.1 Is Edge Information Sufficient for Object Recognition; Evidence from Empirical Research

Given the minimal importance attributed to surface details by proponents of edge-based accounts of object recognition, the absence of colour in an image should not disadvantage the naming of the object featured therein. By contrast, it is argued that the naming of line drawings might actually be more efficient than that of realistic images as they provide clearly defined edges thus removing the need to extract edge information (Biederman, 1987). An early study by Biederman and Ju (1988) set out to explore this by identifying those factors involved in primal access, the first contact between an isolated, unanticipated object, and a representation in memory. They conducted five experiments in total, which varied in terms of the tasks used, the intensity at which the images were presented, and whether or not the images were followed by a mask. Three experiments employed a naming task (Expt 1: high intensity, mask; Expt 2: low intensity, mask; Expt 3: low intensity, no mask); two employed a verification task (Expt 4: low intensity, mask; Expt 5: low intensity, no mask). In all experiments, performance was compared across colour photographs and line drawings. Their findings provide little support for Biederman's (1987) hypothesis. Indeed, while there was a slight, non-significant advantage for line drawings in the first experiment, there was no overall difference in the ability of participants to recognise common objects presented as colour photographs or line drawings. By contrast, experiment three reported a significant advantage of the colour photographs, though they were unable to replicate this advantage in experiment five, which was matched for test conditions but employed a verification task. They concluded that edge information was sufficient for primal access; however, they recognised that surface details might contribute to object recognition in certain situations. Thus, surface details were recognised as useful at the later, semantic stage of object recognition, when the objects featured were unusual or had similar volumetric shape (e.g. file-knife; Biederman & Hilton, 1987), when the objects were degraded or occluded (Biederman & Ju, 1988), and in the case of mass nouns (e.g. water, snow, sand) for which colour becomes diagnostic (Oliva & Schyns, 2000).

Although several other studies conducted around this time provided support for edge-based theories of object recognition by failing to demonstrate an advantage of colour over black and white photographs in object classification and other semantic tasks (Davidoff & Ostergaard, 1988; Ostergaard & Davidoff, 1985), subsequent studies have demonstrated that surface details do play a role in object recognition, documenting an advantage for the naming of colour photographs over line drawings (Funnell, Hughes, & Woodcock, 2006), colour photographs over black and white photographs (Brodie, Wallace & Sharrat, 1991, experiment 3; Davidoff & Ostergaard, 1988; Price and Humphreys, 1989; Tanaka & Presnell, 1999; Williams & Tanaka, 2000), and for coloured computer images over greyscale images (Wurm, Legge, Isenberg, & Luebker, 1993). Although these findings are at odds with edge-based accounts, as the presence of surface details appears to be beneficial for object recognition, interestingly many of these later studies advance on the ideas of Biederman and Ju (1988), in that the extent to which surface information facilitates object recognition is dependent upon the properties of the object.

2.3 A ROLE FOR SURFACE DETAILS IN OBJECT RECOGNITION?

Though there is now a large body of evidence to suggest that surface information aids object recognition (Brodie, Wallace & Sharrat, 1991, experiment 3; Davidoff & Ostergaard, 1988; Funnell, Hughes, & Woodcock, 2006; Price and Humphreys, 1989; Rossion & Pourtois, 2004; Tanaka & Presnell, 1999; Williams & Tanaka, 2000; Wurm et al., 1993), there remain a number of findings that contradict this notion (Biederman & Ju, 1988; Davidoff & Ostergaard, 1988; Ostergaard & Davidoff, 1985; Price & Humphreys, 1989). Several methodological issues have been raised that may account, at least in part, for these inconsistencies. Indeed, the use of small numbers of items (Biederman & Ju, 1988; Ostergaard & Davidoff, 1985), and comparisons between line drawings and photographs of similar, though not the same shape (Biederman & Ju, 1988; Price & Humphreys, 1989), might account for the failure of these studies to find an advantage for colour images over line drawings. In addition, it has been argued that under normal viewing conditions, or in basic level object recognition, surface details such as colour do not play a role (Biederman & Ju, 1988). Moving away from the methodological issues, many researchers have noted that the inconsistencies in the literature may also be explained as resulting from interactions between surface details and object properties. Specifically, evidence suggests that (i) colour interacts with shape, and (ii) colour is beneficial for recognition only when objects have high colour diagnosticity. In the following section of this review, both these arguments and the relevant research evidence will be considered, before turning our attention to how this research has informed edge-plus-surface theories of object recognition.

2.3.1 The Role of Surface Details in Relation to Shape

One of the earliest studies to highlight the relationship between the amount of shape information available, and the role of surface information was conducted by Price and Humphreys (1989). Their study was designed to explore the role of colour and photographic detail on the naming and classification of objects from structurally similar and dissimilar categories. They hypothesised that surface details may be more advantageous when the task requires differentiation between stimuli with similar structural descriptions. Thus, surface details may be important for the recognition of items such as animals for example, where many exemplars possess the same properties (e.g. a head, a body, legs, a tail etc.) positioned in similar spatial arrangements across items, making it more difficult to differentiate between items from the same category (e.g. horses are similar in shape to zebra, cows, goats, dogs, deer etc.). By contrast, colour was deemed less important for the recognition of items when structure was inconsistent among category members (e.g. furniture). Indeed, the findings supported their hypotheses in that the finer the degree of differentiation needed, the stronger the effect of surface detail. In this way, it was suggested that colour and other surface details are required to distinguish between representations that are competing for a particular response (Price & Humphreys, 1989).

In keeping with the notion that the role of colour interacts with the amount of shape information available, more recent research suggests that colour is also important when shape information is degraded (Laws & Hunter, 2006; Tanaka & Presnell, 1999). Indeed, although a number of researchers have only found advantages for naming of colour over monochrome images when images are presented clearly (Davidoff & Ostergaard, 1988; Ostergaard & Davidoff, 1985; Rossion & Pourtois, 2004), Laws and Hunter (2006) noted that when images were blurred using a Gaussian filter, colour was found to aid the recognition of living things, though not non-living things. This supports previous work by Tanaka and Presnell (1999) in which colour aided the recognition of blurred objects, though in this instance, this finding was restricted to objects that were highly colour diagnostic. The concept of colour diagnosticity will be discussed in the next section, though it is interesting to note that living things, the recognition of which was aided by the presence of colour (Laws & Hunter, 2006) are typically thought to have higher colour diagnosticity than non-living things. Thus, these results suggest that colour aids the recognition of degraded objects only when that object is typically associated with a particular colour.

2.3.2 The Role of Colour in Relation to Colour Diagnosticity

One possible explanation for the conflicting findings regarding the interaction between colour and shape may relate to the extent to which colour is diagnostic of a given object. This refers to whether or not an object consistently appears in a particular colour. For instance, a banana would have high colour diagnosticity, as it is typically yellow in colour. A car by contrast, would have low colour diagnosticity, as it is not strongly associated with any particular colour. In a study conducted by McRae (1992), participants were found to list colour as a prominent feature of 94% of the living thing concepts they were presented with, though it was much less likely to be considered a feature of non-living thing items. Largely, this finding may account for the discrepancy between the findings of Biederman and Ju (1988) and more recent research. Indeed, many studies that have documented a colour advantage used images of fruits and vegetables (Ostergaard & Davidoff, 1985; Wurm et al., 1993) or other objects with characteristic colours (Price & Humphreys, 1989). Conversely, Biederman and Ju (1988) used only four living thing images, and many of the items used were achromatic (e.g. nail, fork etc.) which may account for the failure to find an effect of colour in all but one experiment.

Though the research cited above provides only post hoc evidence that colour is advantageous for the recognition of objects with high colour diagnosticity, a study by Tanaka and Presnell (1999) found that only the naming of objects with high colour diagnosticity was influenced by the presence or absence of colour. In relation to this, colour diagnosticity has been shown to play a role in scene segmentation, with scenes rich in colour diagnostic content (e.g. rainforests, coasts, deserts) being recognised more readily when presented in appropriate colours or luminance only format, than when presented in inappropriate colours (Gegenfurtner & Rieger, 2000; Oliva & Schyns, 2000). This latter finding is particularly interesting as it highlights the fact that appropriate colour, rather than just the presence of colour is important for scene recognition. Similar findings were reported by Humphrey, Goodale, Jakobson and Servos (1994) in relation to object recognition. They noted that colour was found to be advantageous for the recognition of all living things, though only when the colour was appropriate. Reaction times for the naming of inappropriately coloured objects were not found to differ from those obtained for greyscale items. This was interpreted as evidence that the effect of colour is not restricted to the sensory level as if this were so, (i.e. colour was simply useful for parsing visual information in the same way as texture), then whether or not the colour was appropriate would be of little or no consequence.

Although there is much evidence to suggest that colour is only important for the recognition of highly colour-diagnostic objects, several findings contradict this notion. Indeed, a number of studies incorporating nonliving things, purportedly low colour-diagnosticity items, have reported an advantage for the naming of colour photographs over that of black and white photographs (Davidoff & Ostergaard, 1988) and line drawings (Brodie, Wallace & Sharrat, 1991). Moreover, this advantage was true for as many nonliving as living thing items (Davidoff & Ostergaard, 1988). More recently, Rossion and Pourtois (2004) also demonstrated that colour reduced participants' reaction times across all subcategories of objects, not just those that were highly colour diagnostic, suggesting a role for colour in basic level object recognition.

2.4 EDGE-PLUS-SURFACE ACCOUNTS OF OBJECT RECOGNITION

As is evident from the preceding discussion, there is mounting evidence to suggest that surface details, and in particular colour, are important for object recognition. Moreover, the extent to which surface details facilitate object recognition is seemingly dependent upon a number of variables related to the properties of the object. As such, recent theories of object recognition acknowledge the relationship between shape and surface information, and consider how colour diagnosticity may influence the role of colour. Indeed, although the importance of surface detail was recognised in early theories of object recognition (e.g. Bruner, 1957; Gibson, 1969) only recently have researchers been able to provide specific accounts as to the role of surface details. For example, Tarr and Bülthoff (1998) proposed that surface details are involved in all stages of the object recognition process. Contrary to the edge-based accounts (Biederman, 1987; Marr, 1982; Marr & Nishihara, 1978), that argue object representations are viewpoint-independent, Tarr and Bülthoff (1998; see also Bülthoff & Edelman, 1992; Tarr, 1995; Tarr & Pinker, 1989) claim that representations are viewpoint-dependent, and as such, preserve aspects of the object as it originally appears (Tarr & Vuong, 2002). Therefore, not only is shape information represented, but also many other object properties such as local depth, spatial frequency, and notably colour, texture, and luminance (e.g. Edelman, 1993). In addition, because the temporary representation is dependent on the vantage point from which the object is viewed (Bülthoff & Edelman, 1992; Tarr, 1995; Tarr & Pinker, 1989), they suggest that objects are represented in visual long-term memory as a collection of views, rather than just a single structural representation. The matching of temporary to stored representations is therefore not simply dependent on the structural similarity of the representation to a learned view (Broomhead & Lowe, 1988; Bülthoff & Edelman, 1992; Edelman & Bülthoff, 1992; Edelman, Bülthoff, & Bülthoff, 1999), but also diagnostic features (Tarr, 1995; Tarr & Pinker, 1989) which may relate to shape (e.g. the trunk of an elephant) or to surface (e.g. the stripes of a tiger) information. In this way, both shape and surface information are deemed important at all stages of the object recognition process.

In keeping with the viewpoint-dependent theories of object recognition, a more recent theory outlined by Tanaka, Weiskopf and Williams (2001) also suggests that colour and surface details play a role at all stages of object recognition. Nevertheless, their approach remains in keeping with the ideas of the viewpoint-independent approaches adopted by the edge-based accounts of object recognition (e.g. Biederman, 1987; Marr, 1982; Marr & Nishihara, 1978) in that shape and surface information is necessary for the formation of a viewpoint-independent 2-D representation of the object. Moreover, they acknowledge that object recognition is primarily a shape-driven process, but suggest that colour and texture information are also present in the temporary representation. In this way, surface details are useful in the early stages of visual object recognition (i.e. for object/scene segmentation). More importantly however, Tanaka and colleagues (2001) go further than other edge-plus-surface accounts, to distinguish between the input of visual colour information, and the retrieval of colour information. This is in accordance with studies of brain imaging, which have shown that whilst the frontal and posterior parietal, and inferior temporal regions are activated when participants are asked to identify the correct colour of an object presented in achromatic format (Chao & Martin, 1999; Martin, Wiggs, Altemus, Rubenstein, & Murphy, 1995; Wiggs, Weisberg, & Martin, 1999) the perception of colour is typically associated with activation of the lingual and fusiform gyrus (Chao & Martin, 1999; Martin et al., 1995), suggesting that the perception and retrieval of colour information may be attributed to different brain regions. As such, they suppose that colour knowledge is stored, allowing colour to have a top down influence on object recognition. This is consistent with findings that only appropriate colours aid object recognition (Gegenfurtner & Rieger, 2000; Humphrey, Goodale, Jakobson & Servos, 1994; Oliva & Schyns, 2000), and that colour is only advantageous if diagnostic of the represented object (Tanaka & Presnell, 1999).

Both the viewpoint-dependent accounts (Bülthoff & Edelman, 1992; Tarr, 1995; Tarr & Bülthoff, 1998; Tarr & Pinker, 1989) and Tanaka and colleagues' (2001) account of object recognition are useful in that not only do they clearly outline the role of surface information in object recognition, they suggest that colour may play a role at all levels of the object recognition process. Thus, if we refer back to the three stages described in the introductory paragraph, (i) colour may be useful in segmenting visual inputs to form 3-D object representations (Cavanagh, 1987; Regan, 2000; Troscianko & Harris, 1988); (ii) colour may form a constituent part of the stored object representation, at least for objects for which colour is highly diagnostic; (iii) colour may play a role at the semantic stage of processing, having a top-down influence on object recognition (see Davidoff, 1991; Luzziatti & Davidoff, 1994). This account therefore differs from edge based theories, which suggest a role for colour only at stage (i), and occasionally stage (iii), though only in the case of mass nouns (e.g. water, sand, soil – where colour becomes diagnostic; Oliva & Schyns, 2000), rare objects, objects with similar volumetric shape (e.g. blackbird, thrush), and degraded or occluded objects (Biederman & Ju, 1988).

There are a growing number of studies, which provide support for the notion that surface information, particularly colour is important at all stages of object recognition. Much of the supporting evidence for the edge-plus-surface accounts, has been discussed above (e.g Price & Humphreys, 1989; Tanaka & Presnell, 1999) however both accounts fail to specify how colour information is stored. For instance, is colour and shape information stored within the same representation, or separately within semantic memory? Evidence from the neuropsychological literature (e.g. Riddoch, 1984; Riddoch & Humphreys, 1987 a & b; Riddoch, Humphreys, Coltheart & Funnell, 1988) suggests that shape and colour information are stored separately. The cases of JB and HJA (Riddoch & Humphreys, 1987 a & b respectively) show that despite loss of stored colour knowledge, knowledge of shape was largely unimpaired. As such, a number of researchers have suggested that there are separate representations for shape and colour, (consistent with neurological evidence; Zeki, 1993) though given that these properties interact to facilitate object recognition; these representations are likely to be highly interconnected (Humphrey, Servos, Goodale & Jakobson, 1994; Price & Humphreys, 1989). In relation to this, both of the edge-plus-surface accounts discussed have specifically emphasised the top-down role of colour. However, several studies have demonstrated that other surface details, particularly texture may aid object recognition (Brodie, Wallace & Sharrat, 1991; Humphreys, Goodale, Jakobson & Servos, 1994; Price & Humphreys, 1989). Thus, texture knowledge, for example, may also be stored in semantic memory.

2.5 OBJECT RECOGNITION IN RELATION TO CATEGORY-SPECIFICITY

Thus far, this review has been concerned with the perceptual characteristics of the object recognition process; what visual information is necessary for the formation of temporary object representations, and ultimately the retrieval of object information from semantic memory. In addition, we have briefly considered how top-down processes can inform object recognition, and how information relating to an object's shape and colour may be organised in semantic memory. In relation to this, we have also explored evidence of an apparent interaction between shape and surface information. Interestingly, this may have significant implications for any area of research that has relied heavily on the use of object identification and discrimination tasks to inform theoretical understanding. A good example of this would be the study of semantic memory, and in particular the research into category specific effects in both neurologically impaired and intact individuals as a means of furthering our understanding of the structure of semantic memory.

Category-specificity refers to the relative impairment of one domain of knowledge with respect to another. In particular, researchers have focussed on apparent dissociations in peoples' ability to recognise living things (e.g. animals, flowers, fruits etc.) and nonliving things (e.g. vehicles, buildings, furniture etc.). Category specific deficits have been documented across a broad spectrum of neurological impairments including herpes simplex encephalitis (HSE; Warrington & Shallice, 1984), and Alzheimer's dementia (AD; Gonnerman et al., 1997; Silveri et al., 1991). In recent years, the majority of studies have explored category-specificity in AD patients. Within this population, it is assumed that damage to semantic memory, the repository of conceptual knowledge (Chertkow and Bub, 1990; Hodges, Salmon & Butters, 1991; Done & Gale, 1997), underlies the observed naming impairments (e.g. Bayles, Tomoeda & Trosset, 1990; Chertkow and Bub; 1990; Laws, Gale, Leeson and Crawford, 2005).

Whether or not naming impairments in AD are category specific has been the subject of much research. Typically, research has shown that AD patients show a deficit for living things, though the opposite trend has been reported, albeit to a lesser extent (for review see Laws, Adlington, Gale, Moreno-Martínez, & Sartori, 2007). However, a recent meta-analysis of 21 studies looking at category-specificity in over 500 AD patients, and 500 controls (Laws, et al., 2007a) reported that patients were impaired in their ability to recognise items from both the living and nonliving thing categories when compared to controls. Moreover, it showed that although the majority of individual studies documented a higher number of living thing deficits than nonliving thing deficits (13:8 respectively) there was no significant difference in the overall effect sizes for living and nonliving things. This finding is somewhat surprising given the prevailing view that most previous studies indicate a living thing deficit for this patient group. Laws and colleagues (Laws et al., 2007a) highlighted a number of factors that could account for their finding, though of particular interest here is the tendency of researchers to make within-group comparisons, rather than comparing patient performance to that of healthy controls, and the tendency of researchers to use monochrome images in object identification tasks. Both of these factors will be discussed presently, though concerning the former, we will explore the importance of knowing whether or not category specific effects occur in the normal population, and how image modality may influence normal performance on picture naming tasks.

2.5.1 Category Effects in healthy participants; an artefact of image format?

As highlighted by Laws and colleagues (Laws et al., 2007a; Laws, Gale, Leeson & Crawford, 2005) the prevailing view that AD patients more commonly show a deficit for living things may to some extent be attributed to the tendency of researchers to make within-group comparisons, rather than comparing patients to controls. Indeed, Laws et al., (2005) demonstrated that such within-group comparisons could distort both the degree, and type of impairment documented. Despite this, the category specific literature is dominated by reports of category effects in neurologically impaired patients (e.g. Bunn, Tyler, & Moss, 1998; Cappa, Frugoni, Pasquali, Perani, & Zorat, 1998; Laiacona & Capitani, 2001; Mauri, Daum, Sartori, Reisch, & Birbaumer, 1994; Samson, Pillon, & De Wilde, 1998; Sartori & Job, 1988), whilst only recently have researchers turned their attention to how these reports relate to normal performance. Moreover, as with the neurological data, there is some discrepancy as to whether healthy participants exhibit category effects, with several studies reporting a nonliving thing advantage (Coppens & Frisinger, 2005; Gaffan & Heywood, 1993; Humphreys, Riddoch, & Quinlan, 1988; Lloyd-Jones & Humphreys, 1997), though others have found a living thing advantage (Brousseau & Buchanan, 2004; Filliter, McMullen, & Westwood, 2005; Gerlach, 2001; Låg, 2005; Laws, 2000; Laws & Neve, 1999; Laws & Hunter, 2006; Lloyd-Jones & Luckhurst, 2002; McKenna & Parry, 1994). These disparate findings have largely been attributed to (i) a failure to match across category on nuisance variables such as familiarity, visual complexity, and age of acquisition (e.g. Gaffan & Heywood, 1993; Humphreys, Riddoch, & Quinlan, 1988; Lloyd-Jones & Humphreys, 1997); (ii) a skewed distribution in the naming of healthy participants, with a tendency for performance to be at ceiling (e.g. Låg, 2005; Laws, 2000; Laws et al., 2003; Laws & Hunter, 2006); and (iii) a tendency to employ line drawings (e.g. Barbarotto et al., 2002; Coppens & Frisinger, 2005; Gale, Laws, & Foley, 2006; Gerlach, 2001; Laws & Neve, 1999). Points (i) and (ii) have been discussed in Chapter 1, therefore it is point (iii) that will be discussed here.

The majority of studies of healthy controls within the category specific literature have employed images taken from the Snodgrass and Vanderwart (1980) corpus. This is a large set of 260 line drawings of familiar items, taken from a wide variety of living and nonliving subcategories, and with normative data for a number of nuisance variables. Though widely used, as line drawings they lack surface details such as texture, luminance, and colour, all of which are thought to play a role in object recognition (Regan, 2000). More importantly however, there is mounting evidence to suggest that surface details are more important for the recognition of certain categories of objects, dependent on the properties of the object. Indeed, as previously discussed, surface details have been shown to be more influential in naming when items are structurally similar (Price & Humphreys, 1989; Wurm et al., 1993), and in particular, colour has been found to facilitate naming only when an object has high colour diagnosticity (Humphrey, Goodale, Jakobson & Servos, 1994; Tanaka & Presnell, 1999). Crucially for category specific research, living things are arguably more structurally similar, and have higher colour diagnosticity than nonliving things. As such, using the black and white drawings of the

Snodgrass and Vanderwart (1980) corpus may automatically disadvantage the recognition of living thing items.

In recent years, several studies have been carried out to explore the extent to which the category effects observed in healthy participants may actually be an artefact of the use of line drawings. For example, Rossion and Pourtois (2004) compared the name agreement and reaction times of healthy participants across category, presenting all participants with the original Snodgrass and Vanderwart (1980) items, as well as colour and greyscale versions of these items. They found colour to improve the recognition of all objects (both living and nonliving) under normal viewing conditions, but in keeping with earlier research (Price & Humphreys, 1989; Wurm et al., 1993), this advantage was more pronounced for objects such as fruits and vegetables that are highly structurally similar and have high diagnosticity values, than for structurally dissimilar nonliving items. Largely consistent with this, Zannino and colleagues (Zannino, Perri, Caltagirone, & Carlesimo, 2007) demonstrated that normal controls were able to name living things significantly better when they were presented as colour photographs, than as line drawings, though no advantage was found for nonliving things.

In contrast, the findings of Laws and Hunter (2006), suggest that under normal viewing conditions, colour may not aid the recognition of living things any more than that of nonliving things. Indeed, they found a living thing advantage under normal viewing conditions, which occurred regardless of whether the images were presented in colour or black and white. However, they did find an interaction between image format and category when the images were blurred. In this instance, colour was found consistently to aid the recognition of the blurred images. Interestingly, there was no correlation between error rates and the colour diagnosticity of the items in either the normal or blurred viewing condition, suggesting that colour may play a role in the recognition of all items when shape information is degraded, not just those with high diagnosticity. Though colour was not found to interact with category under normal viewing conditions, the fact that colour was found to aid the recognition of living things when the images were blurred might have some implications for the use of black and white line drawings in the study of category specific impairments in neurologically impaired individuals. Whilst it is unlikely that blurring the images replicates the experiences of agnosic patients, to some extent it may be applicable to the interpretation of patient data, especially as it is in keeping with findings from studies of agnosic patients (Viggiano, Vannucci & Righi, 2004; Yip & Shina, 2002).

2.5.2 Could colour influence naming in AD patients?

In light of the foregoing, it is important to consider also the potential implications of using line-drawn images with neurologically impaired individuals in the study of category specific impairments. As is the case with neurologically intact participants, the majority of studies using AD patients employ line drawings. Indeed, the meta-analysis conducted by Laws et al., (2007a) noted that of the 21 studies of category specific deficits in AD that were reviewed, only six used colour images, with the remaining 15 using line drawings. The findings of the meta-analysis were however inconsistent with what might be inferred from studies with healthy participants. They reported that although a significant difference in effect size emerged for living things presented in colour and monochrome (1.55 vs. 2.64), the difference between the monochrome and colour effect size for nonliving things was not significant (1.45 vs. 1.85). As such, performance appeared to be worse with colour than with monochrome images, though this was only significant for living things. This finding was attributed to the visual impairments common to this group of patients (Cronin-Golomb, Sugiura, Corkin, & Growdon 1993; Kurylo et al., 1994; Pache et al., 2003; Rizzo, Anderson, Dawson, & Nawrot, 2000; Wijk, Berg, Sivik, & Steen, 1999).

Nevertheless, the findings of Laws and colleagues (Laws et al., 2007a) are at odds with the findings of previous research with agnosic patients (Humphreys & Riddoch, 1987; Humphrey, Goodale, Jakobson & Servos, 1994; Mapelli & Behrmann, 1997; Young & Ellis, 1989), which has shown colour to have a positive effect on object recognition, particularly for living things. Indeed, early findings indicated that although patients with visual form agnosia are generally impaired in the recognition of real objects, they fair better with these than with line drawings (Humphreys & Riddoch, 1987). Moreover, agnosic patients have also been found to perform better with colour images than with monochrome line drawings (Humphrey, Goodale, Jakobson & Servos, 1994; Young & Ellis, 1989), particularly with images of living thing objects (Humphrey et al., 1994).

Despite the fact that the absence of colour appears to be more detrimental for the naming of living things than that of nonliving things in agnosic patients, only two studies have looked at the effect of colour on category naming in AD. The earliest, conducted by Montanes and co-workers (Montanes, Goldblum, & Boller, 1995) had AD patients and healthy controls name monochrome line drawings and colour figures, and noted that AD patients only showed a deficit for living things when presented with monochrome line drawings. This therefore suggests that the use of monochrome images may disadvantage the naming of living things in AD patients. However, it is worth noting that the images used in the different modalities, were taken from different living and nonliving categories, with animals, vegetables, vehicles and objects being represented in colour, and only animals and objects represented in monochrome. As such, it is possible that factors other than the format of presentation could account for the findings of Montanes et al., (1995). Nonetheless, recent research by Zannino, Perri, Caltagirone, and Carlesimo (2007) does provide some support to the findings of Montanes and colleagues (Montanes, Goldblum & Boller, 1995). Using colour and monochrome versions of the same living and nonliving thing items, they found that both AD patients and healthy controls were able to name living things significantly better when they were presented as colour photographs than as line drawings. Furthermore, when compared to healthy controls, AD patients only showed a significant deficit for the naming of living things when the images were in line-drawn format, thus supporting the notion that the predominant use of line-drawn images within the category specific literature may account for the emergence of a naming deficit penalizing living things.

2.6 CONCLUSIONS

A review of the literature suggests that theories of object recognition are shifting away from the simple edge-based accounts, as mounting evidence highlights the importance of surface information at all stages of the object recognition process. Indeed, research findings from studies of both neurologically intact and impaired individuals lend support to the surface-plus-edge theories of object recognition, in particular that put forward by Tanaka, Weiskopf and Williams (2001). Consistent with this account, surface details, particularly colour, are thought to aid object recognition in situations where shape information is degraded (Laws & Hunter, 2006; Tanaka & Presnell, 1999), but also when making choices between structurally similar items (Price & Humphreys, 1989) when the object is strongly associated with a particular colour (Tanaka & Presnell, 1999). Importantly, these findings suggest that, as the objects' properties determine the usefulness of surface details, this information may be more beneficial for the recognition of certain categories of objects, specifically living things such as fruits and vegetables (Tanaka & Presnell, 1999). Consequently, the ideas put forward by proprietors of the surface-plus-edge theories of object recognition have been discussed in terms of their implications for the study of category-specificity, in relation to both neurologically intact and impaired populations, given that the prevailing view is of a disadvantage for living things. Regarding the former, research suggests that colour is more important for the recognition of living things than nonliving things in the healthy population, under both normal (Humphrey, Goodale, Jakobson & Servos, 1994; Rossion & Pourtois, 2004; Tanaka & Presnell, 1999) and degraded (Laws & Hunter, 2006) viewing conditions. Similarly, though there are only a limited number of studies that have specifically addressed the issue of a format by category interaction in AD patients, the majority of studies suggest that the use of monochrome images may disadvantage items from the living thing category (Montanes, Goldblum & Boller, 1995; Zannino, Perri, Caltagirone & Carlesimo, 2007), though there is some evidence to the contrary (Laws, Adlington, Gale, Moreno-Martinez & Sartori, 2007). Taken in conjunction with the knowledge that the majority of studies within the category specific literature have used line drawings taken from the Snodgrass and Vanderwart (1980) corpus, it may be that the predominant view of a living thing deficit is an artefact of the format of the images used. As such, further research is needed to evaluate the extent to which category specific effects are independent of format.

Chapter 3: The Hatfield Image Test (*HIT*): A New Picture Test and Norms for Experimental and Clinical use.

3.1 INTRODUCTION

Picture naming is an informative and widely used marker of perceptual and cognitive processing by the human brain, and a large body of literature now exists describing the factors that predict naming accuracy under normal and pathological brain function. The vast majority of studies within this broad literature use images derived from the Snodgrass and Vanderwart (1980) corpus (e.g., Ardila, Ostrosky-Solis, Rosselli, & Gómez., 2000; Berndt, Burton, Haendiges, & Mitchum, 2002; Dell'Acqua, Lotto, & Job, 2000; Köhler, Moscovitch, Winocur, & McIntosh, 2000; Laws, Gale, Leeson, & Crawford, 2005; Laws & Neve, 1999, Ousset, Viallard, Puel, Celsis, Demonet, & Cardebat, 2002; Pashler & Harris, 2001; Pechmann & Zerbst, 2002; Stark & Squire, 2000; Van Petten, Senkfor, & Newberg, 2000; Ward & Parkin, 2000). This renowned picture set comprises 260 small line drawings of everyday objects derived from a range of subcategories. The Snodgrass and Vanderwart (1980) corpus also includes normative data, collected from a large subject pool, for the following variables that are known to affect object identification: object name agreement, concept familiarity, image agreement, and visual complexity.

Despite the widespread and continuing use of the Snodgrass and Vanderwart (1980) stimuli in psychological and linguistic research over the past three decades (as testified by its still achieving 100+ citations per year: Scopus database, 2008), the corpus has several drawbacks. One issue of concern is that the 260 items are depicted only as simple line drawings: indeed, a number of studies have highlighted the significance of colour in object recognition, both in neurologically intact and impaired individuals (e.g., Grossman, Galetta, & D'Esposito, 1997; Laws & Hunter, 2006). For example, surface details such as colour and shading may be crucial for recognising objects in situations where information relating to shape is inadequate (Laws & Hunter, 2006; Tanaka & Presnell, 1999). A second issue is that there is little graded structure with regard to picture naming difficulty: indeed, under normal viewing conditions, healthy participants invariably name the majority of items with ease. This can be problematic in studies that compare error rates between brain-injured patients and a normal cohort, since the latter will generally perform at ceiling levels with this picture set (see Laws, 2005; Laws et al, 2005). While other copora such as the Boston Naming Test do have a graded structure, they still suffer from being line-drawn and from ceiling effects (for reviews, see Kent & Luszcz 2002; Hawkins & Bender, 2002). Psychometrically, naming tasks conducted using the Snodgrass and Vanderwart (1980) corpus, and the Boston Naming Test display negative skew (asymmetry) and extreme kurtosis (Hamby, Bardi, & Wilkins, 1997) making it difficult to detect differences at the average to higher average levels of performance.

One important reason why the Snodgrass and Vanderwart corpus have been so widely used is that the authors provided an accompanying series of subjective ratings for the images, which have proved extremely useful to researchers. Indeed, psycholinguistic variables (also known as "intrinsic variables") have a well-documented impact on the processing of both pictorial and verbal material (e.g. in the study of naming across semantic domains: for a review see, Moreno-Martínez & Laws, 2007); and therefore need to be carefully controlled to prevent them from confounding results (e.g. Funnell & Sheridan, 1992; Stewart, Parkin, & Hunkin, 1992). Indeed, using hierarchical regression, Gale, Irvine, Laws and Ferresey (2009) estimated that almost 40% of the variance in naming for Alzheimer patients was attributable to these psycholinguistic variables. More recently, a number of researchers have developed new stimulus sets in an attempt to provide some more ecologically valid object representations, either by producing coloured variants of the Snodgrass and Vanderwart pictures (Rossion & Pourtois, 2004) or by creating novel sets of coloured photographs (e.g. Viggiano, Vannucci, & Righi, 2004). The normative data provided with these picture sets varies significantly, but notably none provide ratings for age of acquisition, a variable that has been shown to be a powerful predictor of object naming performance in both normal and brain-injured individuals (Holmes, Fitch, & Ellis, 2006; Moreno-Martínez, & Peraita, 2007).

Moreover, existing image sets include a majority of highly familiar everyday objects and so do not directly address the problem of ceiling level naming performance in the normal population. Indeed, although it may be possible to select subsets of items for which naming accuracy is below ceiling, such sets would be too small to allow across subcategory comparisons of performance. Thus, although such stimuli are suitable for studies using reaction time as the dependent variable, as this paradigm prevents the emergence of ceiling effects; the ceiling effect for naming accuracy in healthy participants constitutes a serious drawback for studies. One way in which researchers have attempted to overcome ceiling level performance is with bootstrapping techniques (Delucchi & Bostrom, 2004; Moreno-Martínez & Laws 2007, 2008), which require fewer assumptions about the distribution of data than needed for parametric tests. Another way to ensure that naming accuracy is not at ceiling is to use stimuli that are graded in difficulty; however, high familiarity sets of stimuli again make this difficult to achieve. Of course, naming tasks are often relatively easy for healthy subjects because the stimuli have generally been developed for clinical use. Nonetheless, experimental researchers would also clearly benefit from the availability of high quality stimuli that avoid ceiling effects.

In an attempt to address the issues outlined above, we present a new corpus of colour images (the Hatfield Image Test: *HIT*) and associated normative data. The images consist of high quality colour photographs presented against a plain white background and have been specifically chosen to: (i) represent a broad range of taxonomic subcategories; and (ii) capture a wider range of item naming difficulty, whereby some pictures show very well known items, while others show relatively unfamiliar ones. All images are free from copyright and are readily available to researchers to download (http://testbed.herts.ac.uk/HIT/hit_apply.asp). We present normative data for the following variables: naming accuracy, age of acquisition, colour diagnosticity, familiarity (to name and to picture), name agreement (and *H*- statistic), visual complexity and word frequency[2].

[2] Image Agreement (IA), i.e. a rating based on how closely a rater's mental image to the name of an item matches the actual target image, has been found to predict naming accuracy (Alario et al., 2004; Snodgrass & Yuditsky, 1996). We decided, however, not to measure IA because ratings require that participants *know* each item from the name. While it has been possible to derive IA ratings for existing corpora, largely because they are highly familiar items, most participants would not be familiar with the majority of *HIT* items – and so, make it difficult to obtain reliable IA ratings on any items that are not highly familiar.

3.2 METHOD

3.2.1 Description of HIT materials

Item Selection

One hundred and eighty-nine images were collected depicting items chosen to represent the following 15 subcategories: animals, birds, insects, flowers, body parts, fruit, vegetables, clothing, tools, vehicles, musical instruments, buildings, kitchen utensils, food, and furniture. As such, a broad range of subcategories was chosen to represent both living and nonliving things, with the inclusion of some subcategories that have produced interesting dissociations (e.g. *fruit/vegetables and animals* – Caramazza & Shelton, 1998; Hart, Berndt, & Caramazza, 1985; Hillis & Caramazza, 1991; Laws & Gale, 2002; *body parts*[3] – see Barbarotto, Capitani, & Laiacona, 2001; Laws, Gale, Frank, & Davey, 2002; *musical instruments* **-** Silveri & Gainotti, 1988; Warrington & Shallice, 1984). For each subcategory, we collected items intended to cover high, medium and low familiarity ranges.

Obtaining the Images

We obtained a colour photograph for each selected item. The first author photographed some items, and the remainder were obtained via online sources. In the latter cases, we conducted an internet search for images using the most common name for each item. We selected images to provide the most canonical view (i.e. views where the major axes of the objects were not foreshortened and the critical features were not occluded); and depicted items were presented in the orientation that provided maximal visual information, e.g. for some fruits, internal detail was available in the image because it is regarded as important to recognition (see McRae & Cree, 2002). Authorization to use all these images for research purposes was obtained from the appropriate photographer or website.

[3] Including internal body parts (cf. most of the existing stimuli tend to be body parts visible to the naked eye, though see Pérez & Navalón, 2003, for an example of where line drawings of internal body parts have previously been used).

Standardisation

Images were removed from their original backgrounds and were standardised whereby the maximal vertical or horizontal dimension of each object was set at 283 pixels. All images were positioned on a plain white background. Each image was oriented (left -or right-facing) in accordance with the normative data obtained by Viggiano and Vannucci (2002), generalising their findings to subcategories not featured in their original study (i.e. kitchen utensils were oriented with the handle to the bottom left corner as this was the preferred direction for tools). The final images were saved as Bitmap files.

Figure 3.1 Examples of high quality photographic images from the *HIT*

Choice of final HIT pictures (n=147)

Initially, all 189 images were presented to a sample of 152 participants (see participant section below for details) for naming. We subsequently excluded items that were named by less than 10%, of this sample. The final set of items comprised 147 items (see Appendix A) deriving from seven biological and eight man-made object subcategories. Example images are presented in Figure 3.1.

3.2.2 Normative data collection

Participants

As previously mentioned, we tested a sample of 152 healthy participants (69 males: 83 females) of mean age 35.15 years (*SD* = 20.15). The mean number of years of education for the participants was 13.85 (*SD*=2.5; range 8-21 years). All had normal or corrected-to-normal vision, and English was their first language.

Procedure

Participants were tested individually in a single session lasting approximately forty minutes, with no rest period during testing. Each experimental session was preceded by a practice phase to enable each participant to become familiar with the task, and to allow the development of anchor points for the stimulus ratings. Each participant saw nine images in the practice phase and all were derived from subcategories that were not included in the main stimulus set. Images were presented on a laptop computer.

Participants were asked to complete a naming task and one of four tasks rating the images for either: familiarity (n= 42: 23 female 19 male), visual complexity (n= 37: 21 female 16 male), age of acquisition (n= 31: 16 female 15 male), or colour diagnosticity (n= 42: 23 female 19 male). Subjects were randomly assigned to these conditions (except for the proviso that comparable numbers of males and females made the ratings).

During the test phase, the 147 images were presented in random order using the *Testbed (V 1.0)* software package (Noel Taylor, University of Hertfordshire, 2006). Each image was preceded by a cross (+) for 500ms, and a brief blank screen (150ms) and remained on the screen until the participant responded. Participants were asked to name the item, and to rate it on the variable assigned to them. If participants were unable to recognise an item or named it incorrectly, they were provided with the correct name before being asked to rate the item for familiarity, age of acquisition or colour diagnosticity, to ensure participants were rating the concept rather than the image. Ratings of visual complexity were obtained in relation to the image rather than the concept. All ratings, with the exception of age of acquisition, were recorded on a 5-point Likert scale that appeared on screen below the image as radio buttons. Figure 3.2 shows a screen shot of one item (Chinchilla) as presented during testing.

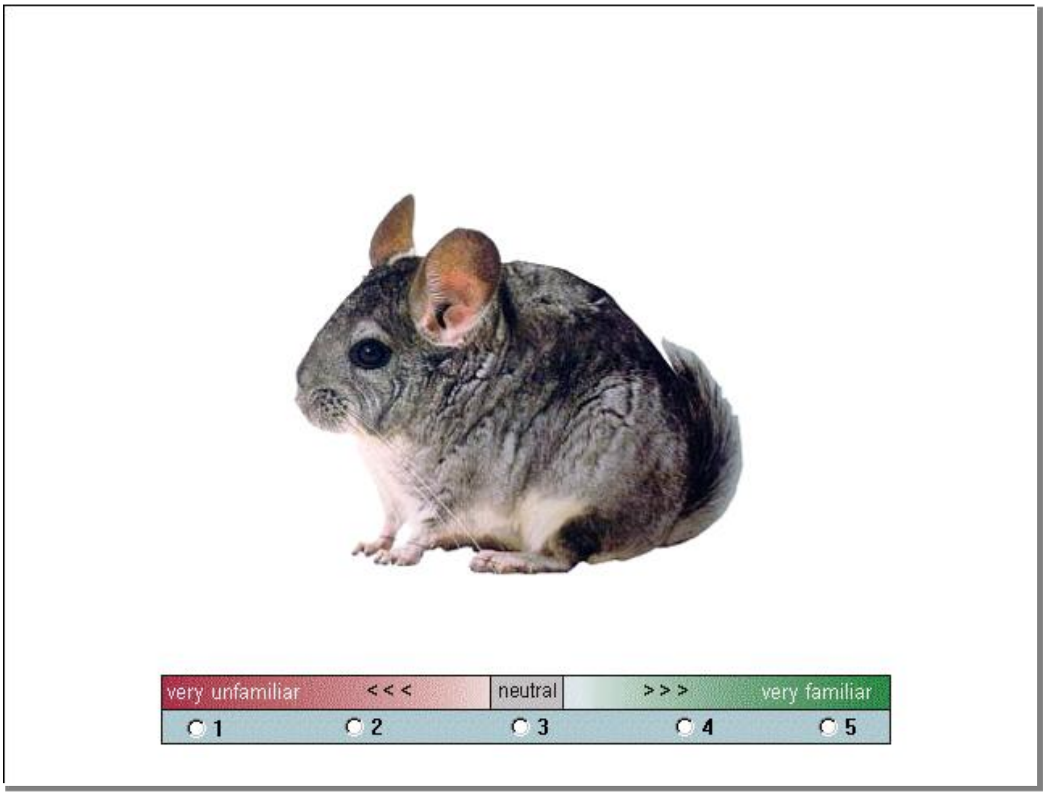


Figure 3.2 A sample screen shot (Chinchilla) from the familiarity-rating task.

Naming task: participants were asked to name each image as briefly and unambiguously as possible, by saying aloud only one name, though the name itself could consist of more than one word. Participants were asked to say 'don't know', if the image was unknown to them, or to say 'tip of the tongue' if they were momentarily unable to remember the name. The experimenter recorded all responses verbatim. When participants were unable to name correctly any item, they were provided with the name and asked to provide ratings. We chose to also include these ratings to cover the full spectrum of responses i.e. not just ratings from those subjects who could correctly name the specific depiction.

The target or dominant name refers to the most commonly produced 'correct' response for each item. Where appropriate, non-dominant names are also included (see Table 2). These largely included synonyms of the dominant name (e.g., <eggplant> for <aubergine>), but occasionally, semantic subordinate responses (e.g., <springbok> for <antelope>; <welsh-dresser> for <dresser>), and semantic-within-category responses of items for which there was some visual or conceptual confusion (e.g., <wasp> for <bee>; <pancake> for <omelette>).

Age of Acquisition: participants were asked to 'estimate the age at which they had learned the name of the object represented in the image'. Participants were asked to record their responses on an answer sheet, by placing a tick in the box that corresponded with one of the following age groups: *2 years; 3 years; 4 years; 5 years; 6 years; 7-8 years; 9-10 years; 11-12 years; 13+ years*. These age groups were chosen to correspond with those used by Carroll and White (1973) to obtain age of acquisition data from adults.

Colour Diagnosticity: participants were asked to rate each item according to 'whether or not the colour of the object depicted is strongly associated with that object, i.e. could that object be in any other colour equally well?' Participants recorded their responses using a 5-point scale (*1 = low colour diagnosticity, 5 = high colour diagnosticity*) by pressing the corresponding number on the keyboard.

Familiarity: familiarity ratings were collected to both the picture and the name (see below). For the picture-based ratings, participants were instructed to rate each item, assessing 'how usual or unusual the concept is in your realm of experience' on the basis of 'how frequently you think about the concept, and how frequently you come into contact with the concept - both in a direct way (seeing a real-life exemplar), and in a mediated way (represented in the media).' We decided to ask for familiarity ratings to the pictures to also ensure that visual familiarity was measured: for example, although recognised to picture, some items may not be named or recognised by name or vice-versa, e.g. subjects may be familiar with the image of a 'Tuk Tuk', but not with the name; or with the name 'Magnolia' but not the appearance of the flower itself. If participants were unable to name the image or answered incorrectly, they were informed of the correct name by the experimenter. Participants recorded their responses on a 5-point Likert scale (*1 = very unfamiliar, 5 = very familiar*) by pressing the corresponding number on the keyboard.

Familiarity to name: A separate group of 35 participants (15 males: 20 females: mean age 29.91 years (*SD*=12.89) were asked to rate the familiarity of the names of the items. The mean number of years of education for the participants was 14.18 (*SD*=3.31). All were native English speaking.

Participants completed an online questionnaire in which they were presented with the names of the items and asked to rate how familiar they were to them. Participants were asked to rate the concept represented by the word, based on 'how usual or unusual it is in your realm of experience', taking 'realm of experience' to mean 'how frequently you come into contact with the concept, both in a direct way (seeing a real life exemplar of the concept) and in a mediated way (seeing that concept represented in the media)'. Again, participants were asked to rate the item on a 5-point Likert scale positioned next to each name, on which *1=very unfamiliar, and 5=very familiar*.

*Name agreement and H statistic:*Name agreement was calculated based on (i) the percentage of participants who named the item according to the correct name, and (ii) the *H* statistic. In contrast to percent correct which indicates only how dominant the most common name is in a sample, *H* is sensitive to how widely distributed responses are over all of the unique names that are provided for a picture. The *H* statistic values, percentage name agreement and all verbatim responses for all 147 items are provided in Appendix B.

$$H = \sum_{i=1}^{k} p_i log_2(\frac{1}{p_i})$$

H was calculated according to the formula outlined above, where *k* is the number of unique names given for a picture, and *pi* is the proportion of the sample providing each unique name. $H = 0$ when there is perfect agreement among participants (e.g., just one name) and increases as agreement decreases.

Visual Complexity: participants were instructed to rate the visual complexity of each image using instructions based on those used by Snodgrass and Vanderwart (1980). They were told to 'rate the visual complexity of the image itself, rather than that of the object it represents', and that visual complexity referred to, 'the amount of detail and intricacy of line in the image'. Participants recorded their responses on a 5-point scale (*1 = very simple, 5 = very complex*) by pressing the corresponding number on the keyboard.

Word frequency: Word frequency estimates were obtained using an internet search engine. The findings of Blair, Urland, and Ma (2002), have demonstrated that this method is a viable alternative to the databases currently available and provides a more representative measure of word frequency. Moreover, this method allows the collection of word frequency values for more unusual items that do not feature in databases such as the CELEX linguistic database (Baayen, Piepenbrock, & Gulikers, 1995), which is more commonly used to obtain word frequency values. The word frequencies obtained from search engines having a high convergent validity with both the CELEX linguistic database (Baayen et al., 1995) and with the Kučera and Francis (1967) database, and show excellent test-retest reliability over a six month period. The AltaVista search engine (www.altavista.com) was selected, given that this is one of the largest search engines currently available, with a database of over 250 million web pages (AllSearchEngines.com, 2000). The name for each item was entered into the search function of AltaVista (compound names were entered inside quotation marks to retrieve the complete name), and a search performed specifying that results should be for the United Kingdom and in English only. The number of hits returned served as the frequency estimate for that word.

3.3 RESULTS

3.3.1 Naming

Figure 3.3 shows the normative naming distribution for items. Items were considered as named correctly when participants provided the dominant or an acceptable non-dominant name (see Appendix B). As can be seen from Figure 3 the naming scores approximated a normal distribution. Computation of the skewness and kurtosis statistics (g_1 and g_2) for the normative sample revealed that skewness was -.05 and kurtosis was 0.10. D'Agostino, Belanger, and D'Agostino's (1990) test for skewness failed to reject the null hypothesis that the distribution was symmetrical: zg_1=-0.25. Further, D'Agostino-Pearson omnibus test for normality, which uses both g_1 and g_2 as input revealed that the distribution did not differ significantly from normality: $K^2 = 0.25$, p=0.88. Table 3.1 shows the summary data for the naming of these images, including the 25th (Q1) and the 75^{th} (Q3) percentiles to aid with the selection of items that represent the easier and harder naming extremes. Although education has been found to modulate naming, it is interesting to note that there was no significant correlation between education and naming accuracy for the *HIT* (r=-0.03, p=0.76).

Figure 3.3 Distribution of naming for the colour *HIT* stimuli

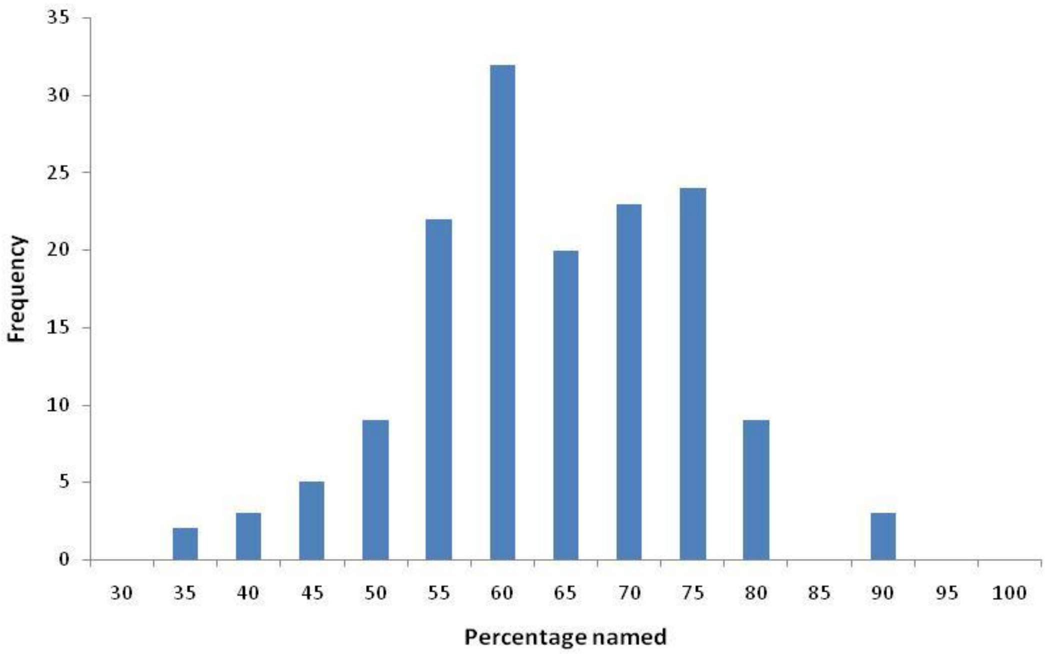


Table 3.1 Summary statistics for naming (percentages) of the colour HIT stimuli

	Naming (%)
M	65.57
SD	11.63
Median	65.99
Range	61.22
Min to Max	32.65 to 93.88
Q1	57.31
Q3	73.45

Note. *Q1, 25th percentile; Q3, 75th percentile*

A two-way ANOVA conducted across subcategory revealed no significant main effect of gender (F_1 (1, 150) = 0.00; *p*>0.05; F_2 (1, 132) =0.74; *p*>0.05; *minF'* (1,189) <1, *p*=0.93). Nevertheless, a significant effect of subcategory emerged (F_1 (14, 150) = 136.74; *p*<0.001; F_2 (14, 132) =2.21;

p=0.01; *minF'* (14,136) =2.17, p=0.01), and a significant gender by subcategory interaction (F_1 (14, 150) = 7.09; p<0.001; F_2 (14, 132) = 5.79; p<0.001; *minF'* (14,275) =3.19, p<0.01).[4]

Table 3.2 shows the breakdown of responses by subcategory. Although simple line drawings may elicit more superordinate responses, this is not the case when naming the high quality colour photos of the HIT, with the rate of superordinate responses being low, i.e. less than 1% for each subcategory.

Table 3.2 Naming responses (%) for each subcategory of the HIT colour stimuli

Subcategory	***Correct (SD)***	***a***	***b***	***c***	***d***	***e***	***f***
Animals (n=8)	50.3 (18.4)	46.0	4.2	20.1	0.1	0.5	29.1
Birds (n=8)	48.6 (24.7)	37.9	10.8	20.9	0.3	0.0	30.2
Body parts (n=10)	85.4 (20.9)	81.8	3.7	4.1	0.0	0.2	10.3
Flowers (n=8)	43.7 (33.6)	42.7	0.9	8.2	0.0	0.0	48.1
Fruits (n=10)	70.6 (27.5)	68.1	2.5	11.6	0.3	0.0	20.0
Insects (n=8)	71.8 (29. 7)	64.4	7.4	13.6	0.7	0.0	13.9
Vegetables (n=9)	54.5 (26.4)	49.6	4.8	14.6	0.1	0.0	30.8
Buildings (n=10)	74.5 (26.2)	70.9	3.5	16.0	0.4	0.1	9.0
Clothes (n=11)	70.7 (25.6)	64.4	6.4	14.9	0.1	0.0	14.2
Food (n=7)	74.7 (24.3)	66.1	8.6	13.6	0.3	0.0	12.3
Furniture (n=12)	72.9 (24.3)	62.9	9.9	14.8	0.0	0.0	12.5
Kitchen utensils (n=12)	68.6 (28.5)	62.9	5.8	9.2	0.6	0.0	21.5
Musical instruments (n=11)	65.3 (22.7)	58.9	6.3	16.3	0.0	0.0	18.5
Tools (n=12)	75.4 (29.4)	70.6	4.8	3.3	0.0	0.0	21.3
Vehicles (n=11)	75.6 (25.6)	66.2	9.5	10.6	0.1	0.0	13.7

Note. (a) dominant response, (b) synonyms, (c) co-ordinates, (d) super-ordinates, (e) sub-ordinates, (f) incorrect answers, and failure to provide an answer

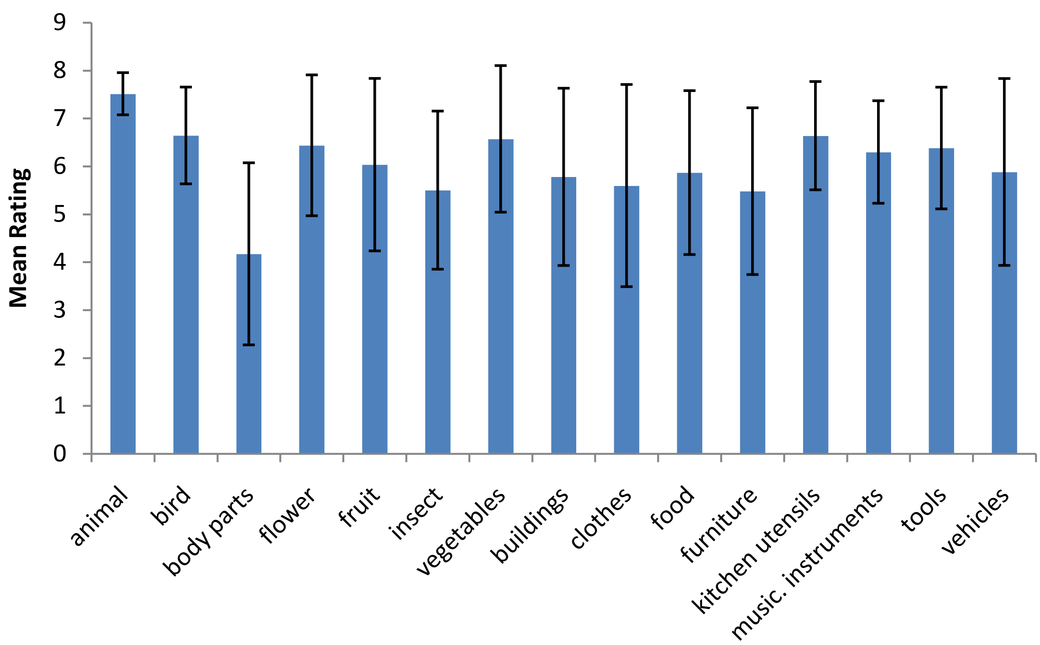
[4] As requested by one reviewer, analyses were also conducted to explore any difference in naming across living and nonliving domains. A two-way ANOVA conducted across subjects (F_1) and across items (F_2) revealed no significant main effect of gender (F_1 (1, 150) = 0.02; p=0.88; F_2 (1, 145) = 0.32; p=0.57; *minF'* (1, 169) <1; p=0.89). There was however a significant effect of category, with better naming of nonliving things (F_1 (1, 150) = 446.01; p<0.001; F_2 (1, 145) = 6.91; p=0.01; *minF'* (1, 149) =6.8; p<0.01); and a significant gender by category interaction (F_1 (1, 150) = 29.39; p<0.001; F_2 (1, 145) = 13.82; p<0.001; *minF'* (1, 169) =9.4; p=0.002); with males naming more nonliving things than females and females naming more living things than males.

3.3.2 The influence of the psycholinguistic variables on naming

Age of Acquisition

The means and standard deviations of the age of acquisition rating for each item are reported in Appendix A. Age of acquisition was found to differ significantly across subcategories (F (14, 132) =2.13, p=0.01). Figure 3.4 shows that body parts had the lowest mean age of acquisition whilst animals attained the highest.

Figure 3.4 Mean age of acquisition ratings across subcategory for the colour HIT

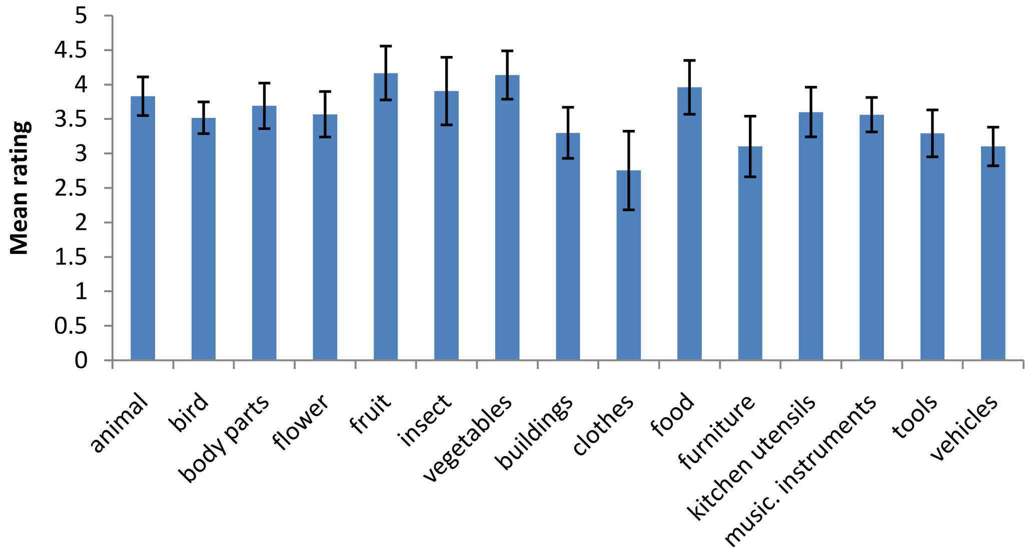


Note: On all figures, error bars represent standard deviation

Colour Diagnosticity

Ratings of colour diagnosticity were collected for each item. The mean ratings and standard deviations for each item are reported in Appendix A. Items are ordered by their dominant name as detailed above. Colour diagnosticity varied significantly across subcategories (F (14, 132) =11.8, *p*<0.001), with higher colour diagnosticity ratings typically ascribed to items from the living thing subcategories, particularly fruit and vegetables, though food was also rated highly.

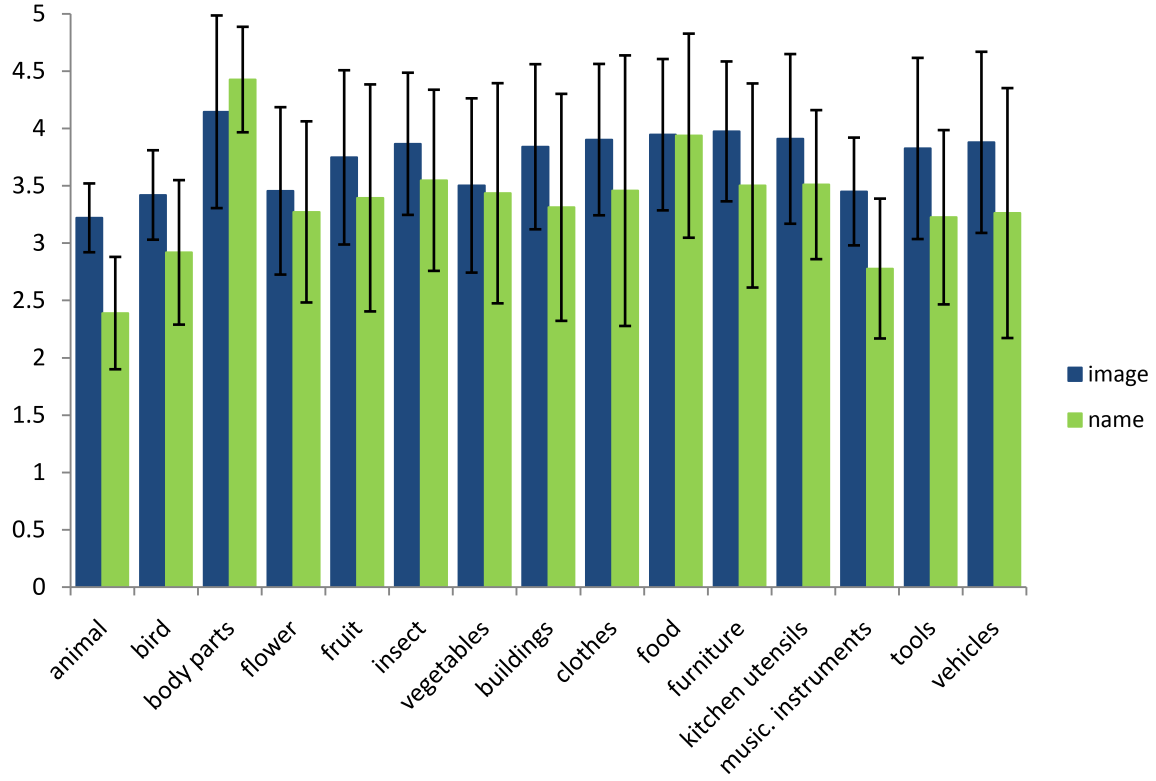
Figure 3.5 Mean colour diagnosticity ratings across subcategories for the colour HIT



Familiarity

Familiarity ratings were collected in reference to the name of the items and the pictorial representations of the items. Appendix A shows the means of both the familiarity to name and the familiarity to image ratings. Pictures are ordered alphabetically by their dominant name within each subcategory. Ratings were found to correlate highly (r=0.83; p<0.001), but nonetheless differed significantly from one another (t=10.08; p<0.001). Across subcategory, ratings to picture were not found to differ significantly (F (14, 132) = 1.35; p=0.19). By contrast, those obtained to the name were found to differ significantly across subcategory (F (14, 132) = 2.79; p=0.001). As Figure 3.6 shows, ratings of image familiarity are higher across all subcategories than ratings of name familiarity, with the exception of body parts. Overall, the highest familiarity ratings are attributed to items from the body parts subcategory, whilst animals and musical instruments have the lowest familiarity ratings.

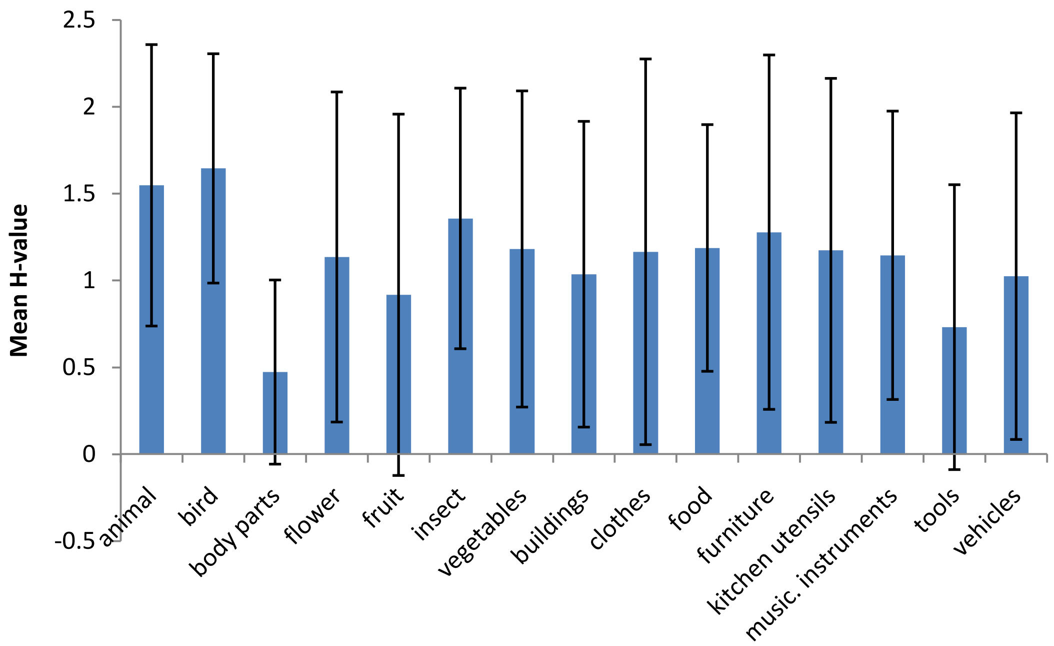
Figure 3.6 Mean familiarity ratings (to image and name) across subcategory for the HIT



H Statistic and Name Agreement

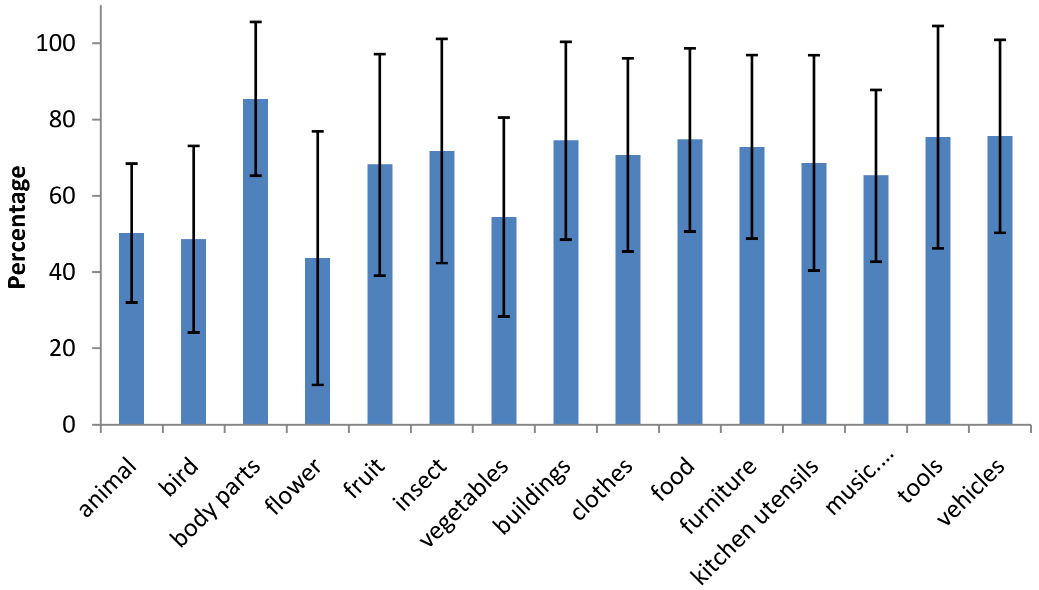
A one-way ANOVA comparing the *H* statistic across subcategory revealed no significant difference ($F(14, 132) = 1.00$; $p=0.46$). Figure 3.7 reveals that body parts had the lowest *H* value, and birds had the highest *H* value based on the number of alternative responses obtained.

Figure 3.7 Mean Name agreement (*H* statistic) across subcategory for the colour HIT



The most dominant name for each item is reported in Appendix B, along with the mean percentage and standard deviation for each subcategory. Items are alphabetically ordered according to the dominant name within each subcategory. Participants generally provided the dominant name for each item more frequently than the non-dominant name; though there were four exceptions (see Appendix B). Responses having no association with the item pictured (e.g., <pellets> for <caviar>), for which the named item might easily be differentiated from the test item (e.g., <sheep> for <llama>; <house> for <bungalow>), or for which no name was given (i.e., don't know, tip-of-the-tongue responses) were grouped as errors. Figure 3.8 shows the mean name agreement and standard deviation for each subcategory. An ANOVA comparing the subcategories revealed a marginal significant difference in name agreement (F (14, 132) =1.86, p=0.04).

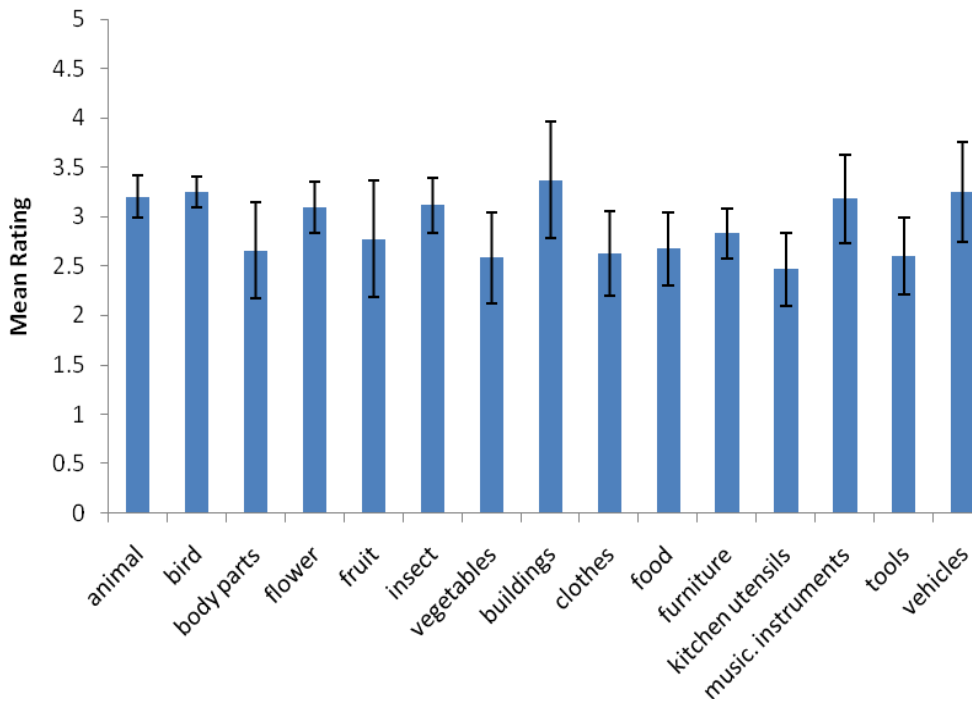
Figure 3.8 Mean name agreement across subcategory for the colour HIT



Visual Complexity

The visual complexity statistics are reported in Appendix A. The mean visual complexity ratings are presented in Figure 3.9. Analysis of visual complexity revealed a significant difference across subcategories (F (14, 132) =5.33, p<0.001), with buildings being more visually complex than all other subcategories.

Figure 3.9 Mean visual complexity ratings across subcategory for the colour HIT



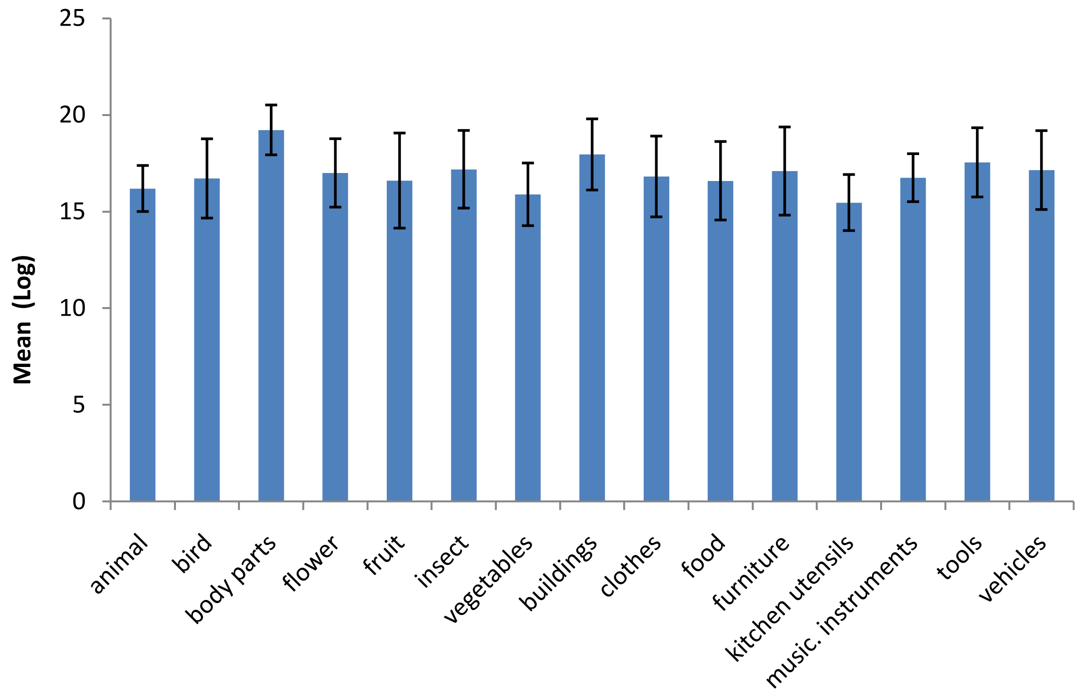
Word Frequency

The word frequency statistics are reported in Appendix A. The word frequency statistics reported correspond with the most accurate name for each item. Word frequency statistics were taken to be the number of 'hits' obtained for each item when entered into the AltaVista UK search engine as described previously. Measures were obtained twice over a six-month period to look at the test-retest reliability of these measures of word frequency. Frequency ratings fluctuated a little over time[5], but were extremely highly correlated (r = 0.99, p<0.001). In addition, a correlation between the word frequency scores for the item names featured in the more commonly used CELEX linguistic database (Baayen et al., 1995), and those used in this investigation, obtained from AltaVista UK, was carried out. For the purpose of this, those items that were not featured in the CELEX linguistic database (19

[5] A web-based measure of frequency is, of course, dynamic i.e. as the absolute number of pages change across time

items[6]) were removed. Both measures of word frequency correlated significantly for the remaining 128 items (r = 0.75, p<0.001). The most recently obtained measures of word frequencies of each subcategory of items are reported in Figure 3.10. The frequencies were converted to their natural log (Lg) to provide a more normal distribution of the frequencies. For word frequency (Lg), there was a significant difference across subcategories (F (14, 132) =2.33, p=0.01), with body parts having a higher frequency than all other subcategories and kitchen utensils being lower than all other subcategories. When these subcategories were removed, the main effect of subcategory failed to emerge (F (12, 125) = 0.75; p=0.70).

Figure 3.10 Mean word frequencies obtained from the number of hits per item on AltaVista UK across subcategory for the HIT



[6] The following items did not appear in the Celex database: arctic fox, celeriac, changing table, coal scuttle, garlic crusher, great-tit, greenfinch, herb cutter, knife sharpener, meerkat, pasta spoon, pizza cutter, samosa, silverfish, snow mobile, starfruit, tuk tuk, umbrella stand, wood plane,

The summary statistics detailed in Table 3.3 provide the 25th (Q1) and the 75th (Q3) percentiles to aid with the selection of items that represent the extremes for each rating. Pearson's correlations were used to establish the extent to which the variables measured (familiarity, age of acquisition, word frequency, name agreement, colour diagnosticity, and visual complexity) correlated with naming scores. The results of this analysis are reported in Table 3.4. As this shows, the naming of the items correlated significantly and highly with most variables, the exception being colour diagnosticity, which failed to correlate with any other variables including naming. After colour diagnosticity, visual complexity showed the smallest correlations with naming and other variables.

Table 3.3 Summary statistics for ratings obtained for the colour HIT

	$F_{(i)}$	$F_{(n)}$	*VC*	*AA*	*WF(Lg)*	*CD*	*H*	*NA %*
M	3.76	3.33	2.89	6.03	16.96	3.53	1.11	67.61
SD	0.69	0.91	0.49	1.67	1.96	0.53	0.89	26.99
Mdn.	3.69	3.34	2.89	6.45	17.00	3.52	1.09	71.23
Skew	-0.08	0.03	0.06	-0.73	0.13	-0.22	0.35	-0.33
Range	2.55	3.66	2.68	6.65	9.15	2.74	3.06	86.14
Min	2.31	1.30	1.70	1.74	12.59	1.95	0.00	13.86
Max	4.86	4.95	4.38	8.39	21.74	4.69	3.06	100.00
Q1	3.26	2.54	2.57	4.81	15.48	3.21	0.29	43.56
Q3	4.33	4.14	3.22	7.32	18.19	3.88	1.86	96.04

Note. $F_{(i)}$ = familiarity to image; $F_{(n)}$ = familiarity to name; VC= visual complexity; AA= Age of acquisition; WF(Lg) = word frequency (log); CD= colour diagnosticity; *H*= *H* Statistic; NA%= percentage name agreement; *Ql* = 25th percentile;*Q3* = 75th percentile

Table 3.4 Correlation matrix for picture naming performance and item ratings obtained for the colour HIT

	F $_{(i)}$	***F*** $_{(n)}$	***VC***	***AA***	***WF(Lg)***	***CD***	***H***	***NA%***
Picture Naming	.88**	.80**	-.27*	-.81**	.51**	.06	-.83**	.98**
$\text{Fam}_{(i)}$		.83**	-.36**	-.86**	.49**	.06	-.71**	.89**
$\text{Fam}_{(n)}$			-.37**	-.86**	.43**	.10	-.64**	.79**
Visual Complexity				.27**	-.06	-.07	.19*	-.26**
Age of Acquisition					-.64**	.03	.69**	-.82**
Word Frequency (Log)						-.05	-.41**	.51**
Colour Diagnosticity							-.09	.05
H statistic								-.83**

Note. $F_{(i)}$ = familiarity to image; $F_{(n)}$ = familiarity to name; VC= visual complexity; AA= Age of acquisition; WF(Lg) = word frequency (log); CD= colour diagnosticity; *H*= *H* Statistic; NA%= percentage name agreement

* < 0.05 level (2-tailed); ** <0.001 level (2-tailed)

3.4 DISCUSSION

The main aim of this investigation was to develop a large new standardised image corpus suitable for both experimental and clinical studies. The *HIT* corpus consists of 147 images available as high quality colour photographs covering a wide range of subcategories, with normative naming data from 152 healthy participants. The images are freely available for experimental use and the following information is provided for each item: (1) the most common name; (2) a measure of name agreement corresponding to the percentage of participants giving the most common name and the *H* statistic; (3) the mean ratings of age of acquisition, colour diagnosticity, familiarity (to name and image), visual complexity, and word frequency values (taken from internet search hits).

Although the use of high quality colour photographic images and provision of normative data for nuisance variables are notable attributes of the *HIT*, perhaps most important is that the naming performance of healthy participants is below ceiling and normally distributed. When the level of performance in healthy participants is often at ceiling (for examples see Laws, 2005), this clearly prevents researchers from accurately exploring trends in normal naming performance. Moreover, the comparison of control data, which is at ceiling, to that of neurologically impaired patients may distort both the degree and type of deficit reported in patients (Laws, 2005; Laws et al., 2005). By contrast, the *HIT* corpus incorporates items of low, medium and high naming difficulty, from which researchers may select appropriately challenging items as required by the testing procedure. Additionally, we note that there were no main effects of education or sex. The former finding certainly does not reflect a restricted educational range since participants had between 8 and 21 years (and ranged from no qualifications through to graduates). This suggests that the *HIT* can be used with male or female participants who have a wide range of educational experiences without requiring test score adjustments for sex and education.

At present, most studies of object recognition rely upon the Snodgrass and Vanderwart (1980) corpus of images (see Laws, 2005; Laws & Gale, 2002; but see Moreno-Martínez & Laws, 2007, 2008) which, though used extensively, has a number of limitations for researchers. First, as the images featured are black and white line drawings, they lack the surface details and colour that may be influential in the recognition of particular subcategories of objects, e.g. fruits and vegetables (Price & Humphreys, 1989; Tanaka & Presnell, 1999), and the ecological validity important in clinical testing (Viggiano et al., 2004). Although simple line drawings are suitable for some testing conditions (e.g. where the stimuli are presented within an experimental framework that either relies upon distorting the images or requires image simplicity), as noted above, neurologically intact participants typically perform at ceiling with confrontation naming and other even more simple tasks such as word-picture matching. Recent developments of both the Snodgrass and Vanderwart images (Rossion & Pourtois, 2004), and of new stimuli sets (Viggiano et al., 2004) do, to some extent, overcome some of the ecological limitations, though the naming performance of neurologically intact participants on these images is, if anything, closer to ceiling. By contrast, the corpus presented here provides high quality colour images on which normative performance covers a range of item familiarity. It is worth noting that the more normally distributed data resulting from the *HIT* are also more likely to satisfy parametric testing assumptions than data derived from existing pictorial tests (for discussion, see Gale, Irvine, Laws and Ferresey, 2009; Moreno-Martínez & Laws 2007; 2008).

One issue that may vary between colour photographs and stylised line drawings is the level of categorical abstraction at which the depicted item tends to be identified. Some items are readily identifiable at quite specific level from their outline shape alone, while others depend more on the presence of colour (e.g. Laws & Hunter, 2006). For example, a line-drawn picture of an apple will typically elicit the basic-level naming response <apple> whereas a detailed colour photograph may elicit a more specific response. By contrast, some breeds of dog have quite distinctive shapes and configurations of features that may assist specific identification, even when shown in a relatively stylised format. Hence, the level at which people identify and name an item depends in part on the quality of visual information, partly on the specific subcategory and also other factors such as context, expertise and so on. Moreover, although the line drawings within the Snodgrass and Vanderwart corpus are generally depicted at the basic-level, this is not the case for all items. For example, the corpus includes several subordinate examples of birds, all of which are atypical. It is a moot point whether the category of birds is actually a superordinate category rather than basic-level, but this only serves to illustrate the difficulties with trying to impose a rigid conceptual hierarchy on a range of different items from different biological and non-biological categories. Given the position outlined above, we did not make any assumptions about the level (basic, superordinate or subordinate) at which items in this corpus should be named. Rather, we examined naming in a large cohort of individuals and observed the most common patterns of responding, reporting also on common misidentifications.

Concerning the relative importance of surface details in object recognition (e.g. Biederman & Ju, 1988; Tanaka, Weiskopf, & Williams, 2001), the current study has some implications. At present, findings relating to the importance of surface details, particularly the role of colour in object recognition are somewhat inconsistent. Indeed, some studies suggest that colour plays an important role in object recognition (Laws & Hunter, 2006; Oliva & Schyns, 2000; Ostergaard & Davidoff, 1985; Price & Humphreys, 1989; Tanaka & Presnell, 1999; Wurm, Legge, Isenberg, & Luebker, 1993); however, others have found that colour has little or no effect on object recognition (Biederman & Ju, 1988). One possible explanation proposed for this difference is that the importance of colour in object recognition may vary as a function of the colour diagnosticity of a particular object (Rossion & Pourtois, 2004). Hence, colour may be more important for the recognition of objects with high colour diagnosticity (that is those objects which consistently appear in the same colour) than for the recognition of objects that are low in colour diagnosticity. In light of this, we have reported ratings on this important variable. Although our colour diagnosticity ratings showed an almost zero correlation with overall picture naming (and indeed all other variables), the ratings do suggest that colour is a more central feature for some subcategories. For example, colour diagnosticity was greater for living things (particularly fruits and vegetables) than non-living things (cf. Rossion & Portois, 2004). Indeed, separate correlational analyses did reveal a significant correlation of colour diagnosticity with naming of the living, but not for nonliving things (r=.33, p=.01 and r=.11, p=.3 respectively). These findings accord with the notion that colour diagnosticity may be more important when structural similarity is high (as has been argued for items from the living thing subcategories: Rossion & Portois, 2004). This may also account largely for discrepant findings, since studies showing an advantage for colour images have used images of fruits and vegetables (Ostergaard & Davidoff, 1985; Wurm et al., 1993) or other objects with high colour diagnosticity (Price & Humphreys, 1989). By contrast, Biederman and Ju (1988), who failed to report a colour advantage, used predominantly non-living items, which would thereby represent the least likely candidates to show use of colour versus effects of colour or colour diagnosticity. We should also recognise that the use of colour versus line-drawn stimuli has implications for studies of neurological patients. For example, a recent meta-analysis of picture naming in Alzheimer patients (Laws, Adlington, Gale, Moreno-Martínez & Sartori, 2007) documented a significantly greater effect size for the naming of colour images than line drawings (and this was especially apparent for images of living things). This does contrast with studies of agnosic patients that have shown colour to have a positive effect on object recognition (Humphrey, Goodale, Jakobson & Servos, 1994; Mapelli & Behrmann, 1997), though not always (Fery & Morais, 2003). Hence, the choice of potentially more realistic colour images over line drawings can have dramatic and somewhat unpredictable effects on the performance of patients and healthy controls.

In summary, the present work provides a new corpus of images, standardised for several important psycholinguistic and cognitive variables, obtained from photographs of real objects, offering a more realistic representation of the visual stimuli featured. As the images are in colour, this also allows a greater degree of manipulation of their physical and perceptual properties, thus allowing researchers to further explore the effects of particular characteristics on visual object recognition. Finally, the broad range of difficulty inherent in the *HIT* permits researchers to select stimuli of appropriate difficulty as required.

Chapter 4: Further Development of the HIT Corpus: Normative Data for Greyscale and Line-Drawn Versions, and a Comparison across Format

4.1 INTRODUCTION

To reiterate the rationale for the Hatfield Image Test (HIT), as discussed in detail in chapter 3, the corpora currently available for use in studies of picture naming are somewhat limited by (i) their tendency to elicit ceiling level performance in healthy controls, owing to the use of very familiar items, and (ii) the use of black and white line drawings, which may lack ecological validity. To address these issues, we have developed the HIT, which features 147 high quality colour photographs of items, graded in naming difficulty.

Although colour images arguably provide greater ecological validity, whether or not colour actually aids object recognition remains a topic of debate. Though it seems intuitively plausible that the presence of colour might aid object recognition in both neurologically intact and impaired individuals, the evidence is not entirely consistent. Indeed, while the majority of studies have shown that colour is advantageous in object recognition (Brodie, Wallace, & Sharrat, 1991, experiment 3; Davidoff & Ostergaard, 1988; Humphrey, Goodale, Jakobson & Servos, 1994; Price & Humphreys, 1989; Tanaka & Presnell, 1999; Williams & Tanaka, 2000), a number of studies have found no effect of image format (Biederman & Ju, 1988; Ostergaard & Davidoff, 1985), and within Alzheimer's dementia (AD) patients, there is even some indication that colour may actually disadvantage object naming (Laws, Adlington, Gale, Moreno-Martínez, & Sartori, 2007).

A number of methodological problems have been highlighted as possible explanations for the discrepant findings in this area. In particular, one concern is that many of these studies make direct comparisons between line drawings and photographs of similar, though not structurally identical items (e.g. Biederman & Ju, 1988; Price & Humphreys, 1989). As such, the shape information available to viewers may differ according to the format of presentation, and given that the role of colour is thought to interact with shape (see chapter 2 for further discussion), this may introduce a potential confound.

Recent attempts have been made to address this issue. Specifically, Rossion and Pourtois (2004) developed greyscale and colour versions of the original Snodgrass and Vanderwart (1980) corpus, in which the images featured were of exactly the same shape. Using these items to test healthy participants, they documented that colour significantly enhanced naming accuracy and elicited shorter response times relative to line drawings. Though these findings demonstrate an important role for colour, the corpus still has a significant drawback; participants performed at near-ceiling level across the line-drawn, greyscale, and colour formats (M= 88.2; M= 89.2; M= 90.3 respectively). The extent to which this corpus could be used to further examine the role of colour in normal object recognition is therefore limited.

Though much research has investigated the role of colour in object naming, relatively little work has been done to assess whether texture information, in the absence of colour, might also influence object recognition. This is surprising given that theories of object recognition acknowledge surface details such as luminance, texture, and colour, as playing a role in the formation of temporary visual representations (i.e. in object/scene segmentation; Biederman, 1987; Marr, 1982; Marr & Nishihara, 1978; Tanaka, Weiskopf, & Williams, 2001). Accordingly, it seems plausible that individuals may be better at recognising objects when they are presented in greyscale (i.e., with textural information available) rather than line-drawn format.

A study by Humphrey and colleagues (Humphrey, Goodale, Jakobson, & Servos, 1994) offers some support for this prediction. Specifically, in experiment 1 of their investigation, these authors compared the naming performance of DF, a 34-year-old female with visual form agnosia, to that of two age matched female controls. Items were presented as real life exemplars, or as colour, greyscale (which they refer to as black and white), or line-drawn slides. DF's naming accuracy decreased with a reduction in surface detail: she performed best when the items were presented in colour, worse when they were presented in greyscale, and worse still when they were presented as line drawings. A similar pattern of performance was reported for the naming latencies of controls, with a significant advantage for colour over black and white, and a significant advantage for black and white over line drawings. This was taken as evidence that surface details such as texture and colour may be more influential in object recognition than previously thought. Though useful in identifying the role of texture information in object recognition, the conclusions of Humphrey and colleagues were based on findings obtained with only two healthy participants. Interestingly, in experiment 2 of their investigation, which looked at the naming latencies of 48 university students, they failed to find a significant main effect of viewing condition, though viewing condition was found to interact significantly with the way in which the objects were grouped according to their perceptual qualities[7].

As with many studies that have compared the effects of image format, one problem with this study is that the items used in each format were similar, but not of exactly the same structure/shape. More recent research has however been carried out using more carefully controlled images. Indeed, Rossion and Pourtois (2004) demonstrated that while naming in healthy participants improves with the addition of colour, the addition of texture information alone (i.e. greyscale) does not significantly improve naming accuracy over that of line drawings. Although this study suggests that texture does not aid object recognition it is important to reiterate that normative performance with this image set is at near ceiling level even when the images are presented as line drawings (with which participants showed the lowest level of naming performance), thus allowing little scope for improvement when surface detail was added.

As discussed already in chapter 3, the Hatfield Image Test (HIT: Adlington, Laws, & Gale, 2009) provides a set of colour photographs for which naming in healthy controls approximates a normal distribution (i.e. ceiling effects are not an inherent problem).This corpus was initially available only in colour but, it has been possible to develop greyscale and line-drawn sets that are exact replicas (in terms of item shape, structure and orientation) of the original items. This chapter reports on the use of these new versions to explore the influence of image format on normative naming. Moreover, additional normative data was obtained for those variables already reported for the colour corpus[8],

[7] Specifically; (i) all objects; (ii) naturally coloured objects; (iii) artificially coloured objects; (iv) colourless objects such as metallic objects; (v) those with surface texture; (vi) those without surface texture.

[8] With the exception of word frequency and familiarity to name, as these were obtained in reference to the item names rather than the images, and therefore, will not differ across the sets.

though given that ratings were obtained in reference to the real life object represented by the item, it is expected that there will be little difference in the ratings obtained for the colour, greyscale and line-drawn items. Nonetheless, ratings of the variables obtained for each format were compared, to explore the extent to which ratings were found to correlate, and to determine the predictive power of these variables. In addition, the extent to which the participant variables of sex, education, and age influenced naming across all three formats was explored.

4.2 METHOD

4.2.1 Participants

A sample of 132 healthy participants[9] (64 males, 68 females; mean age = 44.52, SD = 22.35) were recruited for the purpose of this study. Of these 70 participants (35 males, 35 females; mean age = 45.24, SD = 21.66) viewed the greyscale images, and 62 (29 males, 33 females; mean age = 43.68, SD =23.29) saw the line-drawn images. All had normal or corrected-to-normal vision, and spoke English as a first language.

4.2.2 Materials

To explore the influence of image format on naming, greyscale and line-drawn versions of the 147 colour images featured in the HIT corpus were developed. To develop the greyscale versions, the images were simply entered into the Corel photo-paint software package, and the 'greyscale' function was applied. The Corel photo-paint software was also used to create the line-drawn images. This was achieved using the 'edge finder' function to detect the edges of the images, and to mask surface detail before then converting the images to line drawings, using the 'black and white' function. All images were then saved were then saved as bitmap files for use with the Testbed software, and were

[9] The participants included in this study do not feature in any other study included in this thesis.

presented at 283 x 283 pixels, on a laptop computer using the Testbed (version 1.0) software. Examples of both the greyscale and line-drawn images are displayed in Figure 4.1.

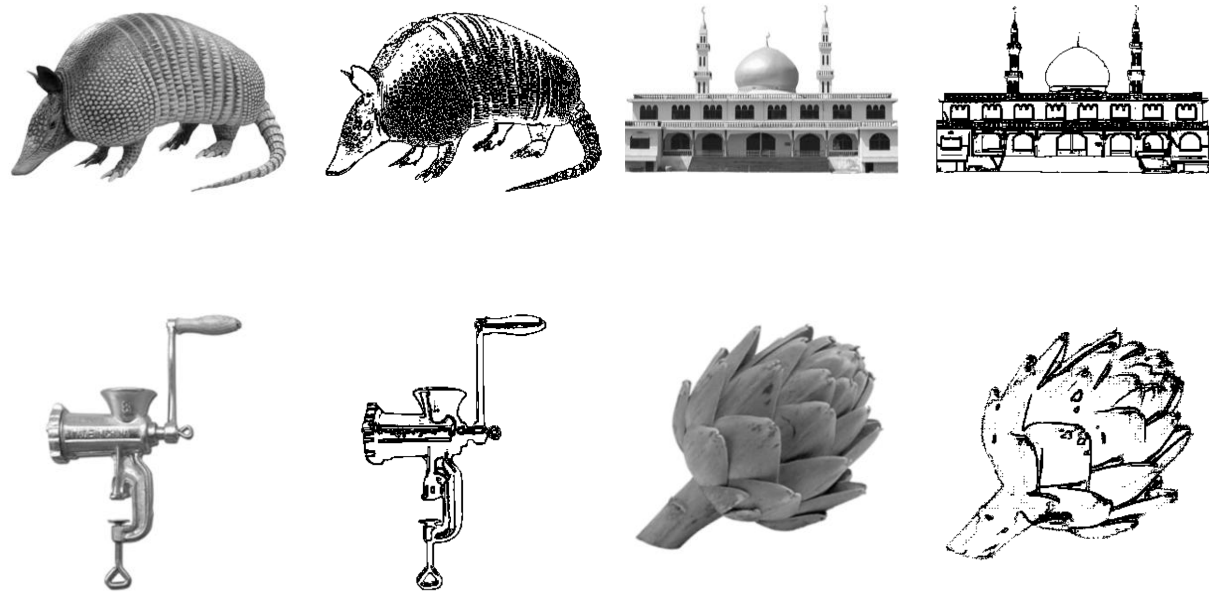


Figure 4.1 Examples of the greyscale and line-drawn images derived from the HIT items (from top left: armadillo, mosque, mincer, artichoke).

4.2.3 Design and Procedure

Participants were tested on an individual basis in a single session lasting approximately forty minutes. Each experimental session consisted of a practice phase and test phase. The practice phase was introduced to enable each participant to become familiar with the task, and to allow the development of anchor points for the stimulus ratings. Each participant saw nine images in the practice phase and all were derived from categories that were not included in the main stimulus set. Images were presented on a laptop computer.

During the test phase, the 147-greyscale images were presented in random order using the *Testbed (V 1.0)* software package (RT Generator Program: Noel Taylor, University of Hertfordshire 2006). Each image was preceded by a cross (+) for 500ms, and a brief blank screen (150ms) and remained on the screen until the participant responded. Participants were asked to name the presented item, and to rate it for either age of acquisition, colour diagnosticity, image familiarity, or visual complexity. Which rating participants were asked to provide was decided pseudo-randomly, with the only determining factor being that approximately equal numbers of participants provided each rating (and that the number of males and females was comparable for each). All ratings, with the exception of age of acquisition, were recorded on a 5-point Likert scale that appeared on screen below the image as radio buttons (see chapter 3, figure 3.2). The individual task descriptions and instructions were the same as those used in the development of the original HIT corpus (see chapter 3).

4.3 RESULTS

As the aim of this investigation was to provide normative data for the greyscale and line-drawn versions of the HIT, the data obtained for the greyscale and line-drawn versions are presented initially. Following on from this, analyses comparing performance across the colour, greyscale, and line-drawn items are presented in section 4.3.3.

4.3.1 Normative data for the greyscale versions of the HIT

Figure 4.2 shows the normative naming distribution for items. As can be seen, this differs somewhat from the distribution of naming for the colour items, with more items named at around 60-70% correct. Skewness and kurtosis (g_1 and g_2) were -0.04 and -0.08 respectively, and D'Agostino, Belanger, and D'Agostino's (1990) test for skewness failed to reject the null hypothesis that the distribution was symmetrical: zg_1=-1.45. Moreover, the D'Agostino-Pearson omnibus test for normality revealed that the distribution did not differ significantly from normality: K^2 = 3.93, p=0.14. As for the colour images (see chapter 3), summary data is provided, (see table 4.1).

Figure 4.2 Distribution of naming for the greyscale *HIT* stimuli

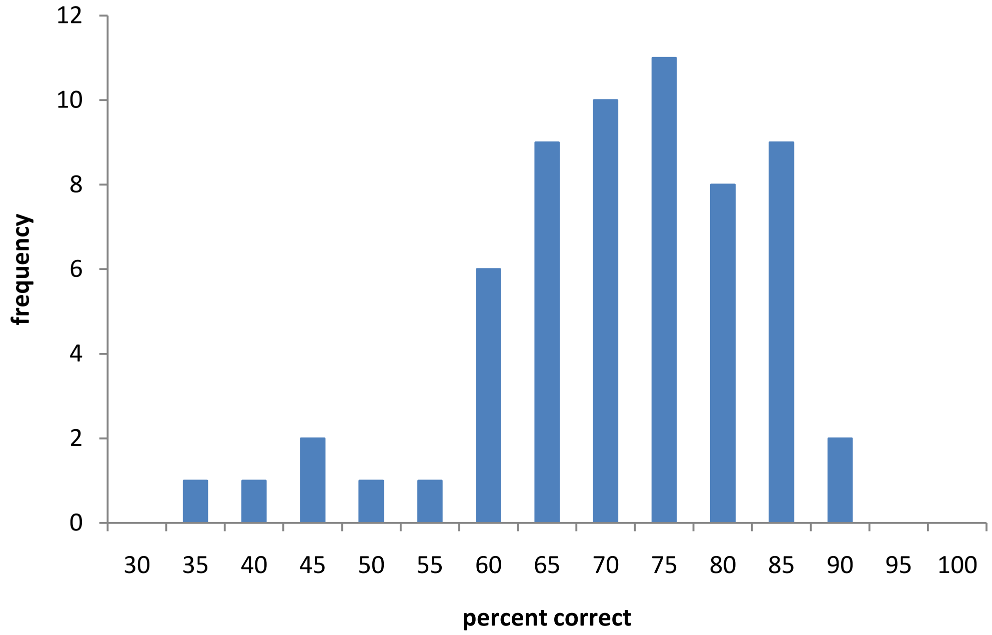


Table 4.1 Summary statistics for greyscale naming (percentages)

	Naming (%)
M	68.36
SD	11.61
Median	69.39
Range	55.78
Min to Max	34.01 to 89.80
Q1	63.10
Q3	76.53

Note. *Q1, 25th percentile; Q3, 75th percentile*

A two-way ANOVA to explore whether sex influenced subcategory (as listed in table 4.2) naming revealed no main effect of sex (F_1 (1,60) = 0.02; p=0.90; F_2(1, 132) = 0.13; p=.72; *minF'* (1, 79) =0.02, p=0.90), but a significant effect of subcategory (F_1 (14, 60) = 39.68; p<0.001; F_2 (14, 132)= 1.93; p=0.03; *minF'* (14, 144) =1.84, p=0.04) and a significant interaction between sex and subcategory (F_1 (14, 60) = 6.60; p<0.001; F_2 (14, 132) = 5.15; p<0.001; *minF'* (14, 129) =2.89, p=0.001). Further exploration revealed that females significantly outperformed males when naming flowers (M=55.15 v 33.93; F (1, 61) = 12.07; p<0.001), and vegetables (M=64.05 v 51.19; F (1, 61) = 5.64; p=0.02). By contrast, males performed significantly better with tools (M=85.12 v 67.4; F (1, 61) = 21.09; p<0.001), vehicles (M=82.47 v 70.05; F (1, 61) = 12.02; p<0.001), and buildings (M=71.18 v 79.64; F (1, 61) = 5.39; p=0.02).

Table 4.2 Naming responses (%) for each subcategory when presented in greyscale format

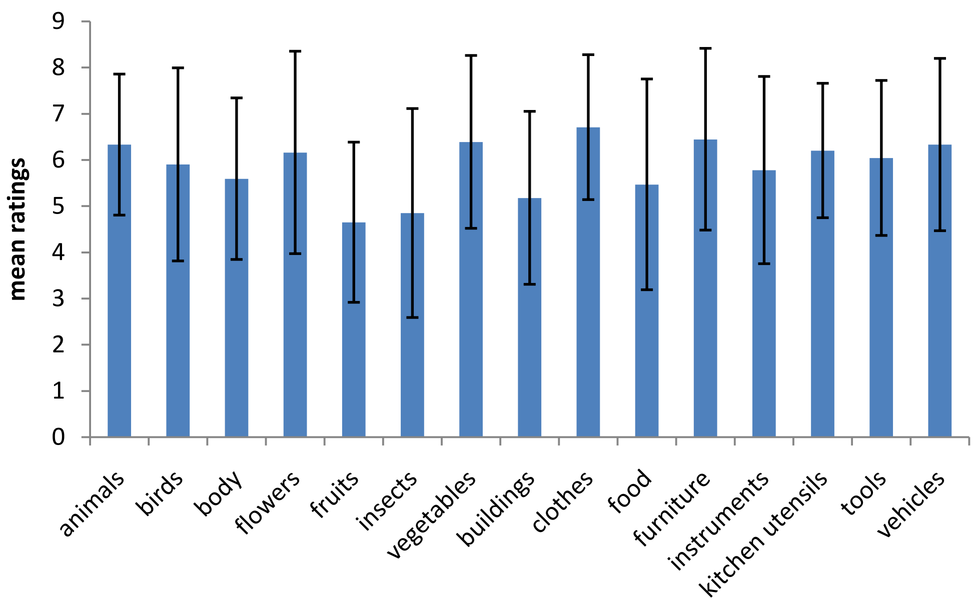
Subcategory	***Correct (SD)***	***a***	***b***	***c***	***d***	***e***	***f***
Animals (n=8)	50.4 (21.8)	40.73	9.68	23.79	2.02	0.00	23.99
Birds (n=8)	48.4 (29.5)	34.48	13.91	27.42	10.28	0.00	14.31
Body parts (n=10)	84.8 (13.2)	83.55	1.29	4.52	0.00	0.00	10.65
Flowers (n=8)	43.6 (17.9)	42.74	0.81	13.91	10.28	0.00	30.04
Fruits (n=10)	66.5 (26.2)	62.58	3.87	12.90	5.65	0.00	15.00
Insects (n=8)	71.2 (22.9)	62.50	8.67	17.74	0.60	0.00	10.48
Vegetables (n=9)	58.4 (22.6)	50.54	7.89	10.93	1.97	0.00	28.67
Buildings (n=10)	75.5 (31.8)	67.74	7.74	11.29	1.61	0.00	11.61
Clothes (n=11)	75.7 (23.8)	66.72	8.94	13.34	1.61	0.00	9.38
Food (n=7)	71.2 (22.13)	57.14	14.06	14.06	3.46	0.00	11.29
Furniture (n=12)	82.9 (25.1)	70.23	12.76	15.25	0.00	0.00	10.85
Kitchen utensils (n=12)	68.2 (26.9)	55.38	13.44	10.48	0.40	0.00	20.97
Musical instruments (n=11)	64.8 (20.2)	53.96	10.85	18.62	1.03	0.00	14.81
Tools (n=12)	75.4 (21.5)	67.74	7.66	6.72	0.81	0.00	17.07
Vehicles (n=11)	75.5 (23.7)	67.30	8.21	11.14	2.05	0.60	11.00

Note. (a) dominant response, (b) synonyms, (c) co-ordinates, (d) super-ordinates, (e) sub-ordinates, (f) incorrect answers, and failure to provide an answer

Age of Acquisition

Ratings of age of acquisition were obtained for each item (using the same instructions as per the colour images), the means and standard deviations for which are displayed in Appendix C. An analysis across subcategory revealed that age of acquisition did not differ significantly (F (14, 146) = 1.06; p=0.40). Figure 4.3 shows that there is little fluctuation in ratings of age of acquisition across subcategory.

Figure 4.3 Mean ratings of age of acquisition across subcategory for the greyscale items

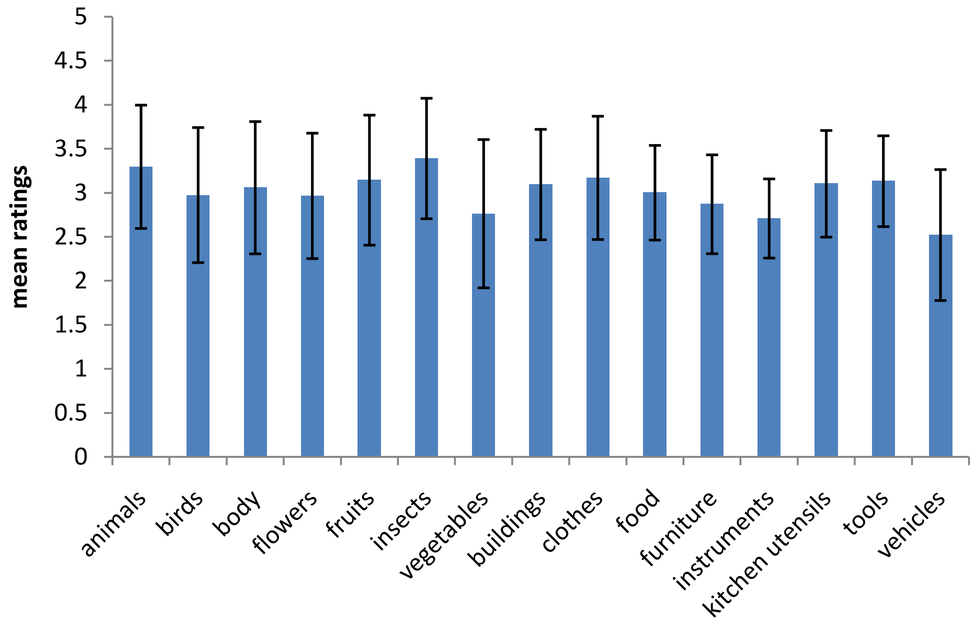


Note. Error bars for all figures in this chapter denote standard deviation.

Colour Diagnosticity

Colour diagnosticity ratings were obtained in relation to each item. These are presented in Appendix C. There were no significant differences in colour diagnosticity across subcategory (F (14, 146) = 1.15; *p*=0.32), as is evident in figure 4.4.

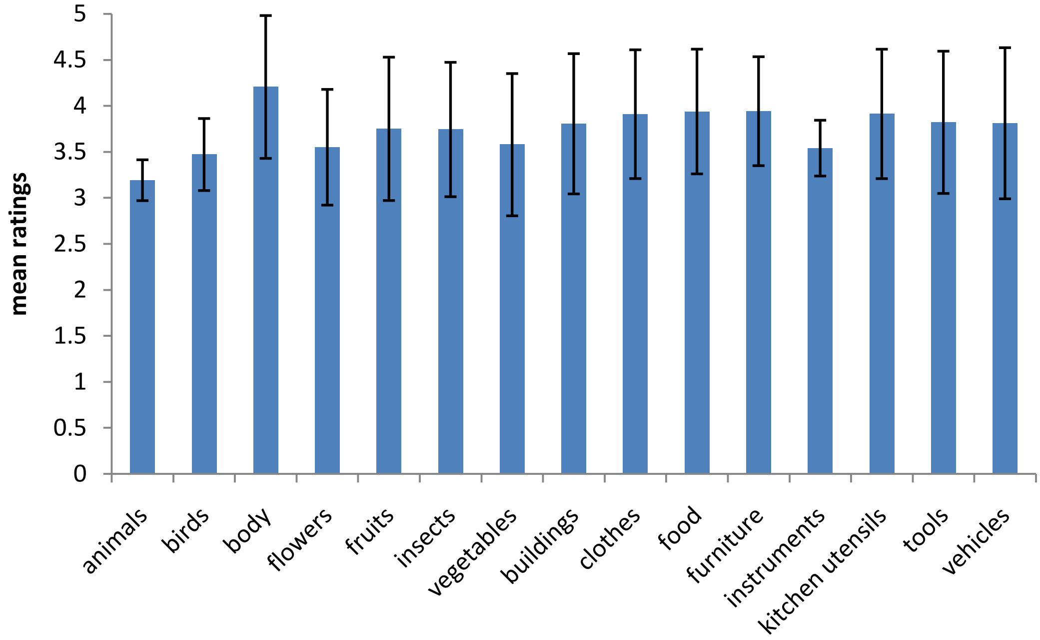
Figure 4.4 Mean ratings of colour diagnosticity across subcategory for the greyscale items



Familiarity

Ratings of familiarity to image were collected for all items, the means and standard deviations for which are presented in Appendix C. A one-way ANOVA revealed no effect of familiarity across subcategory (F (14, 146) = 1.19; *p*=0.29). Indeed, figure 4.5 clearly shows that there is very little variance in familiarity to image across subcategory.

Figure 4.5 Mean ratings of familiarity to image across subcategory for the greyscale items



Name agreement

Two measures of name agreement were obtained for each item; the first related to the number of different alternative names given (*H* statistic), whilst the second was the percentage of participants giving the same answer (% name agreement). The means and standard deviations for both measures are provided in Appendix D. Turning first to the *H* statistic, there was no significant difference in the *H* values obtained across subcategory (F (14, 146) = 1.62; p=0.08). However, there was a difference in the percentage name agreement scores for each subcategory (F (14, 146) =2.25; p=0.01). Figures 4.6 and 4.7 both indicate that body parts have the highest name agreement whilst birds have the lowest name agreement.

Figure 4.6 Mean *H* statistic across subcategory for the greyscale items

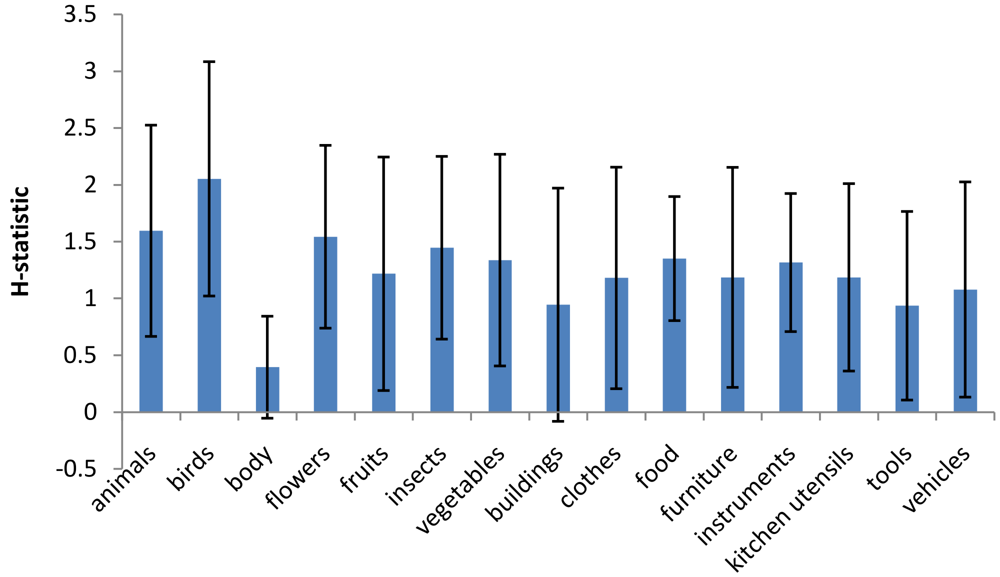
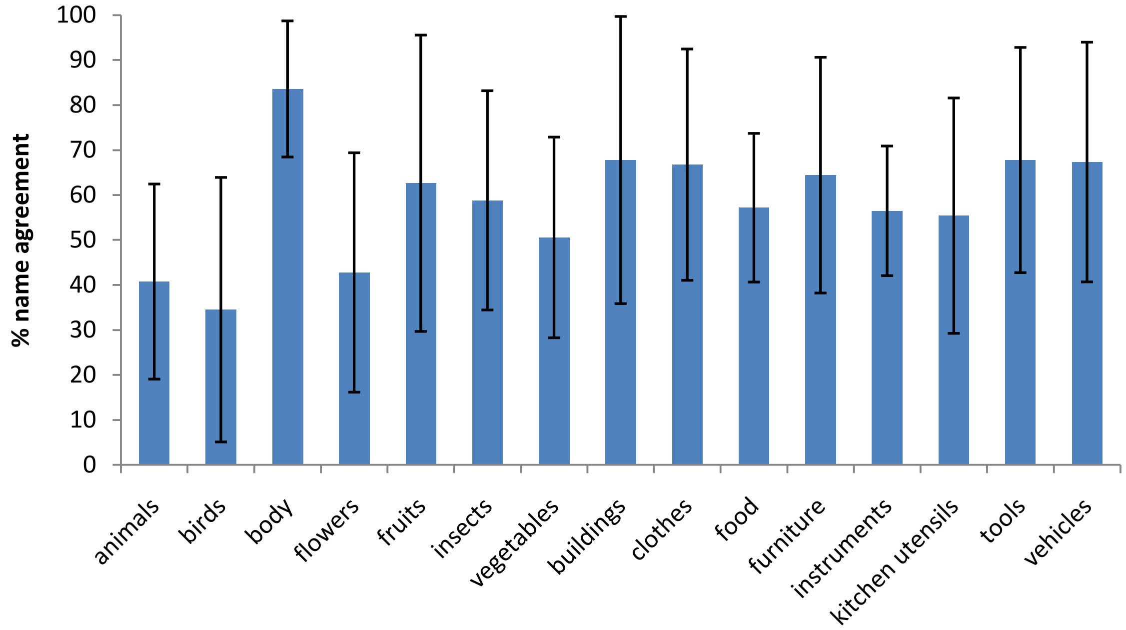


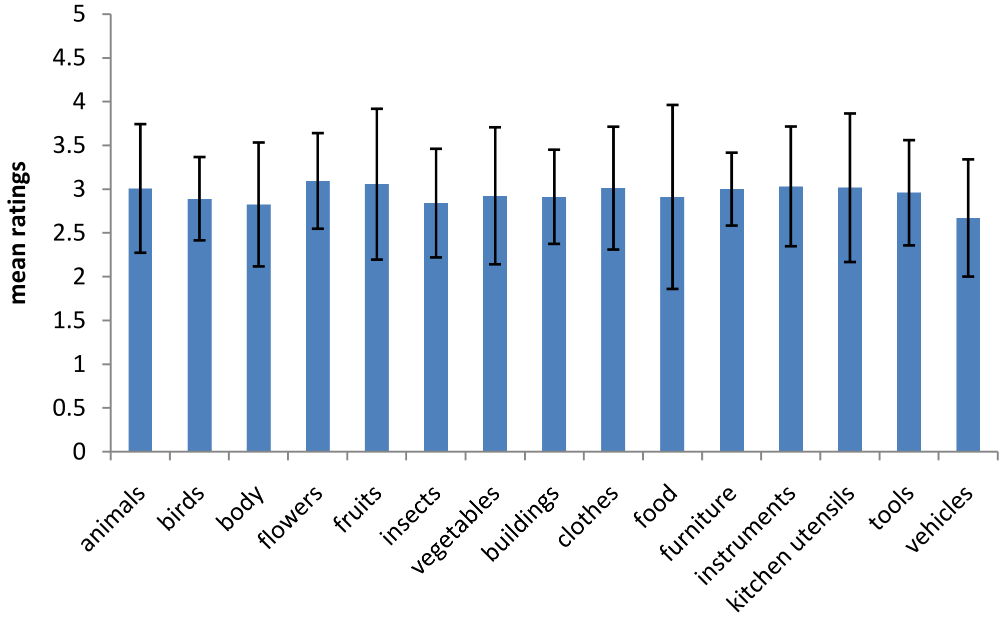
Figure 4.7 Percentage name agreement across subcategory for the greyscale items



Visual Complexity

Visual complexity ratings were obtained for all items, the means and standard deviations for which are presented in Appendix C. As for the majority of factors, there was no significant difference in visual complexity across subcategory ($F(14, 146) = 0.25$; $p = 0.99$). Indeed, figure 4.8 shows that there is very little fluctuation in visual complexity across subcategory.

Figure 4.8 Mean ratings of visual complexity across subcategory for the greyscale items



Summary statistics are provided, including the 25th (Q1) and 75th (Q3) percentiles which may be used to aid selection of items that represent extremes on each rating (table 4.3). Pearson's correlations were conducted to explore the extent to which the variables measured correlated with naming and each other. Table 4.4, shows that picture naming correlates highly with several variables, namely familiarity both to image and name, age of acquisition, word frequency, and both measures of name agreement. Only colour diagnosticity and visual complexity fail to correlate significantly with naming. Interestingly however, these factors were found to correlate positively with one another, thus as ratings of visual complexity increase, so too do ratings of colour diagnosticity. As expected, familiarity, both to name and to image, correlate highly with each other, and this is also the case for the *H* statistic and percentage name agreement.

Table 4.3 Summary statistics for ratings of the greyscale items

	$F_{(i)}$	*VC*	*AA*	*CD*	*H*	*NA %*
M	3.76	2.94	5.89	3.01	1.22	59.56
SD	0.68	0.67	1.87	0.67	0.89	26.67
Mdn.	3.68	3.00	6.36	3.00	1.19	61.29
Skew	-0.04	0.12	-0.52	-0.13	0.28	-0.07
Range	2.53	3.13	7.36	2.93	3.31	91.94
Min	2.35	1.56	1.64	1.29	0.00	8.06
Max	4.88	4.69	9.00	4.21	3.31	100.00
Q1	3.27	2.38	4.50	2.43	1.19	61.29
Q3	4.30	3.50	7.43	3.57	1.97	82.26

Note. $F_{(i)}$ = familiarity to image; VC= visual complexity; AA= Age of acquisition; CD= colour diagnosticity; *H*= *H* Statistic; NA%= percentage name agreement; *Ql* = 25th percentile;*Q3* = 75th percentile

Table 4.4 Correlation matrix for greyscale picture naming performance and item ratings

	$F_{(i)}$	$F_{(n)}$	*VC*	*AA*	*WF(Lg)*	*CD*	*H*	*NA%*
Picture Naming	.83**	.77**	.03	-.18*	.47**	.12	-.83**	.86**
$Fam_{(i)}$		.86**	.06	-.22**	.52**	.10	-.70**	.76**
$Fam_{(n)}$			-.07	-.24**	.62**	.16	-.65**	.70**
Visual Complexity				-.07	-.06	.29**	-.02	.03
Age of Acquisition					-.15	-.04	.12	-.13
Word Frequency (Log)						-.08	-.41**	.48**
Colour Diagnosticity							-.08	.06
H statistic								-.92**

Note. $F_{(i)}$ = familiarity to image; $F_{(n)}$ = familiarity to name; VC= visual complexity; AA= Age of acquisition; WF(Lg) = word frequency (log); CD= colour diagnosticity; *H*= *H* Statistic; NA%= percentage name agreement

* < 0.05 level (2-tailed); ** <0.001 level (2-tailed)

4.3.2 Normative data for the line-drawn versions of the HIT

Figure 4.9 shows the normative naming distribution for the line-drawn items. Akin to both the colour and greyscale versions, the naming scores here also approximate a normal distribution. This is apparent through calculation of the skewness and kurtosis statistics (g_1 and g_2) which were -0.38 and -0.83 respectively. From Figure 4.9 the naming scores approximated a normal distribution. D'Agostino, Belanger, and D'Agostino's (1990) test for skewness failed to reject the null hypothesis that the distribution was symmetrical: zg_1=-1.19. In addition, D'Agostino-Pearson omnibus test for normality revealed that the distribution did not differ significantly from normality: $K^2 = 3.10$, p=0.21. Table 4.5 provides the summary data for naming of the line-drawn items.

Figure 4.9 Distribution of naming for the line-drawn *HIT* stimuli

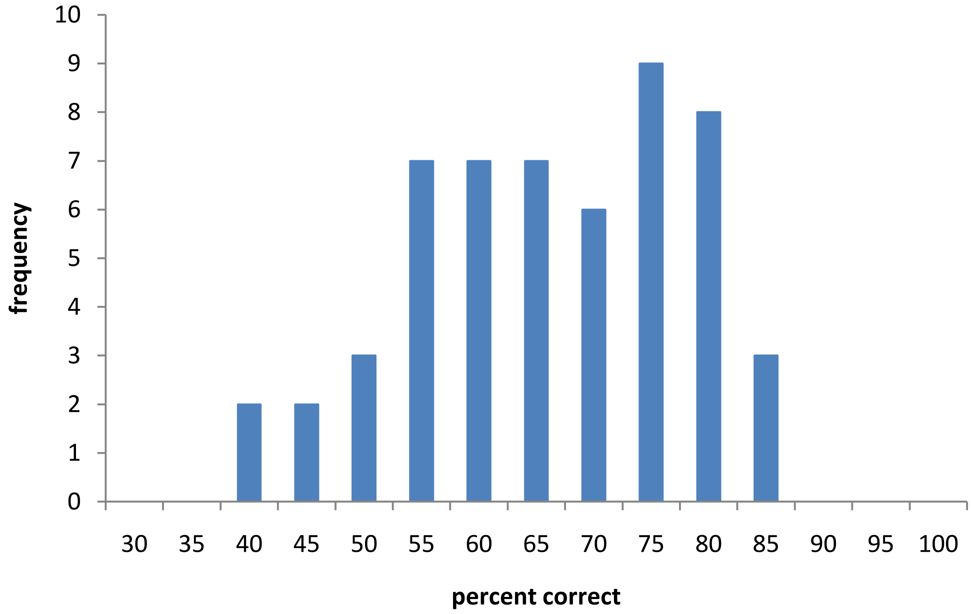


Table 4.5 Summary statistics for line-drawn naming (percentages)

	Naming (%)
M	63.85
SD	11.70
Median	64.63
Range	42.18
Min to Max	38.78 to 80.95
Q1	54.42
Q3	73.64

Note. *Q1, 25th percentile; Q3, 75th percentile*

A two-way ANOVA conducted to explore sex differences across subcategory showed there was no overall main effect of sex (F_1 (1, 52) = 3.89; *p* = 0.05; F_2 (1, 132) = 36.89; p<0.001; *minF'*(1,63) =3.52, *p*=0.07) though both the items and subjects analyses emerged as significant. Nevertheless, analyses revealed a significant main effect of subcategory (F_1 (14, 52) = 54.14; *p* < 0.001; F_2 (14, 132) = 2.59; p=0.002; *minF'*(14, 144) =2.47, *p*=0.004) and a significant sex by subcategory interaction (F_1 (14, 52) = 4.56; *p*<0.001; F_2 (14, 132) = 4.68; p<0.001; *minF'*(14,148) =2.31, *p*=0.01). Further one-way ANOVAs revealed that for those subcategories where significant differences occurred, males consistently outperformed females. Thus, there was a males advantage for insects (M=74.0 v 62.5; *F* (1, 53) = 4.69; *p*=0.04), food (M=53.14 v 41.87; *F* (1, 53) = 6.13; *p*=0.02), tools (M=88.0 v 64.37; *F* (1, 53) = 47.6; *p*<0.001), vehicles (M=82.18 v 67.08; *F* (1, 53) = 11.08; *p*=0.002), buildings (M=77.2 v 69.31; *F* (1, 53) = 5.51; *p*=0.02), and musical instruments (M=60.5 v 71.64; *F* (1, 53) = 6.42; *p*=0.01).

Table 4.6 Naming responses (%) for each subcategory presented as line drawings

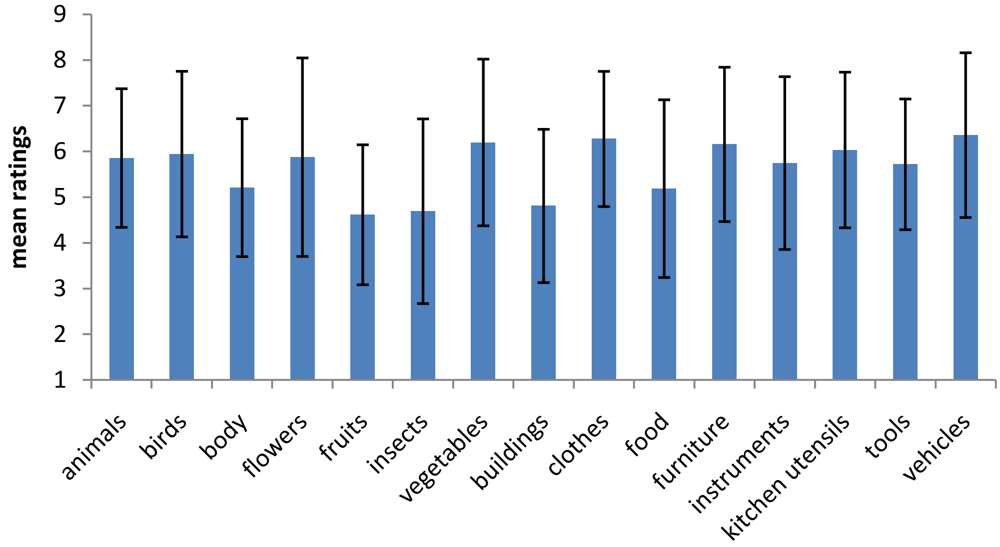
Subcategory	*Correct (SD)*	*a*	*b*	*c*	*d*	*e*	*f*
Animals (n=8)	50.46 (11.2)	37.27	13.19	25.46	3.94	0.00	20.14
Birds (n=8)	48.15 (15.5)	31.94	16.20	33.33	6.71	0.00	11.82
Body parts (n=10)	82.04 (15.7)	80.56	1.48	2.59	0.00	0.00	15.37
Flowers (n=8)	36.3 (15.5)	35.42	0.93	15.51	17.13	0.00	28.70
Fruits (n=10)	55.0 (18.3)	51.85	3.15	19.81	6.11	0.00	19.07
Insects (n=8)	67.4 (15.3)	59.95	7.41	21.30	1.16	0.00	10.42
Vegetables (n=9)	47.1 (18.8)	39.30	7.82	15.23	5.97	0.00	31.69
Buildings (n=10)	75.0 (16.6)	67.78	7.22	12.59	1.67	2.78	9.81
Clothes (n=11)	69.5 (15.7)	62.79	6.73	16.33	1.68	0.00	15.82
Food (n=7)	47.1 (16.7)	27.25	19.84	28.57	0.53	0.00	23.81
Furniture (n=12)	73.9 (12.6)	60.65	13.27	15.59	0.00	0.00	10.80
Kitchen utensils (n=12)	68.52 (12.9)	54.63	13.89	13.12	0.00	0.00	18.36
Musical instruments (n=11)	63.8(13.2)	56.90	6.90	18.01	1.18	3.20	13.81
Tools (n=12)	74.85(13.1)	64.35	10.49	6.79	1.70	0.31	16.36
Vehicles (n=11)	74.24(13.2)	66.50	7.74	12.29	2.19	0.00	11.28

Note. (a) dominant response, (b) synonyms, (c) co-ordinates, (d) super-ordinates, (e) sub-ordinates, (f) incorrect answers, and failure to provide an answer

Age of Acquisition

The means and standard deviations for each item are displayed in Appendix E. Across subcategory, no significant differences in age of acquisition emerged (F (14, 146) =1.16, p=0.19), as is apparent in figure 4.10.

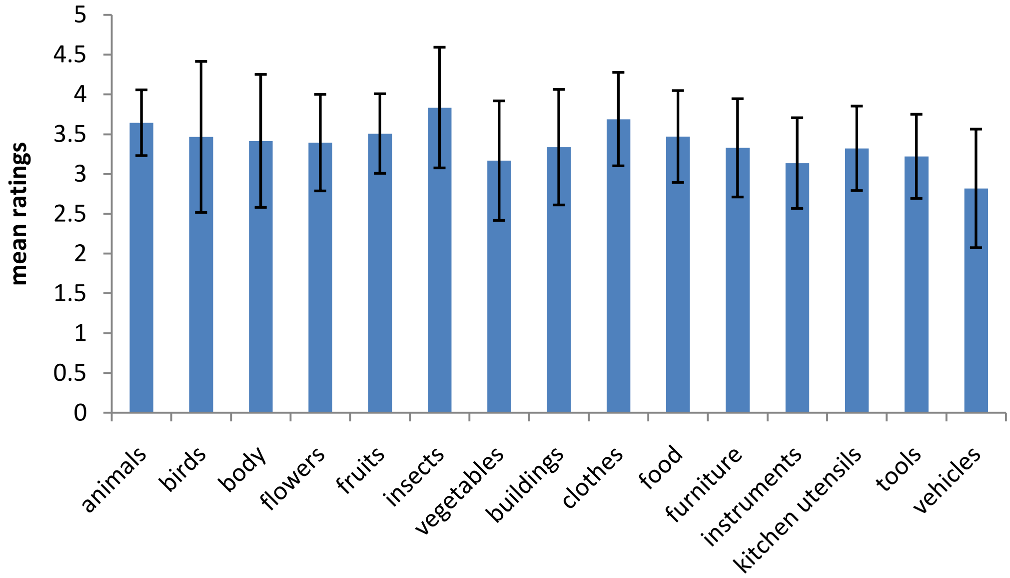
Figure 4.10 Mean ratings of age of acquisition across subcategory for the line-drawn items



Colour Diagnosticity

The mean and standard deviation of the ratings obtained for each item are displayed in Appendix E. Analyses revealed no significant differences in ratings of colour diagnosticity across subcategory (F (14, 146) =1.43, p=0.92). Indeed, figure 4.11 shows that there is little variance between subcategories in ratings of colour diagnosticity.

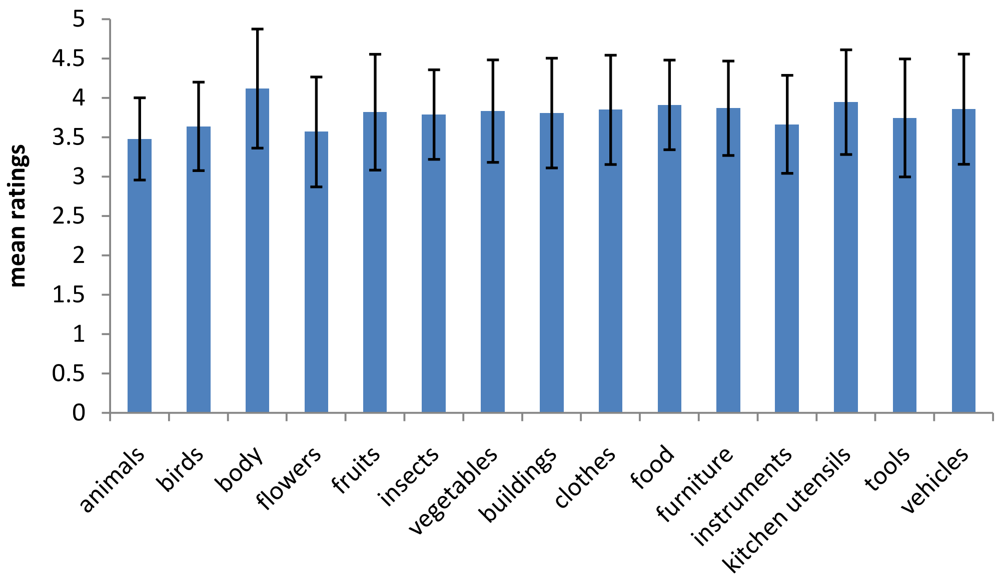
Figure 4.11 Mean ratings of colour diagnosticity across subcategory for the line-drawn items



Familiarity

Ratings of familiarity to the image were obtained for each item, the means and standard deviations of which are presented in Appendix E. A one-way ANOVA showed that there were no significant differences in familiarity across subcategory (F (14, 146) =0.52 p=0.92).

Figure 4.12 Mean ratings of familiarity (to image) across subcategory for the line-drawn items



***H* Statistic and Name Agreement**

Again, both percentage name agreement and the H statistic (based on the number of alternative responses given) were calculated. The means and standard deviations for both are presented in Appendix F. Across subcategory, significant differences were found both for the H statistic (F (14, 146) =2.01, p=0.01), and for percentage name agreement (F (14, 146) =2.59, p=0.003). Regarding the latter, figure 4.13 reveals that body parts have the greatest name agreement, whilst foods have the lowest. This is corroborated by the H statistics obtained for each subcategory, which shows body parts to have the lowest score and therefore largest name agreement (see figure 4.14).

Figure 4.13 Percentage name agreement across subcategory for the line-drawn items

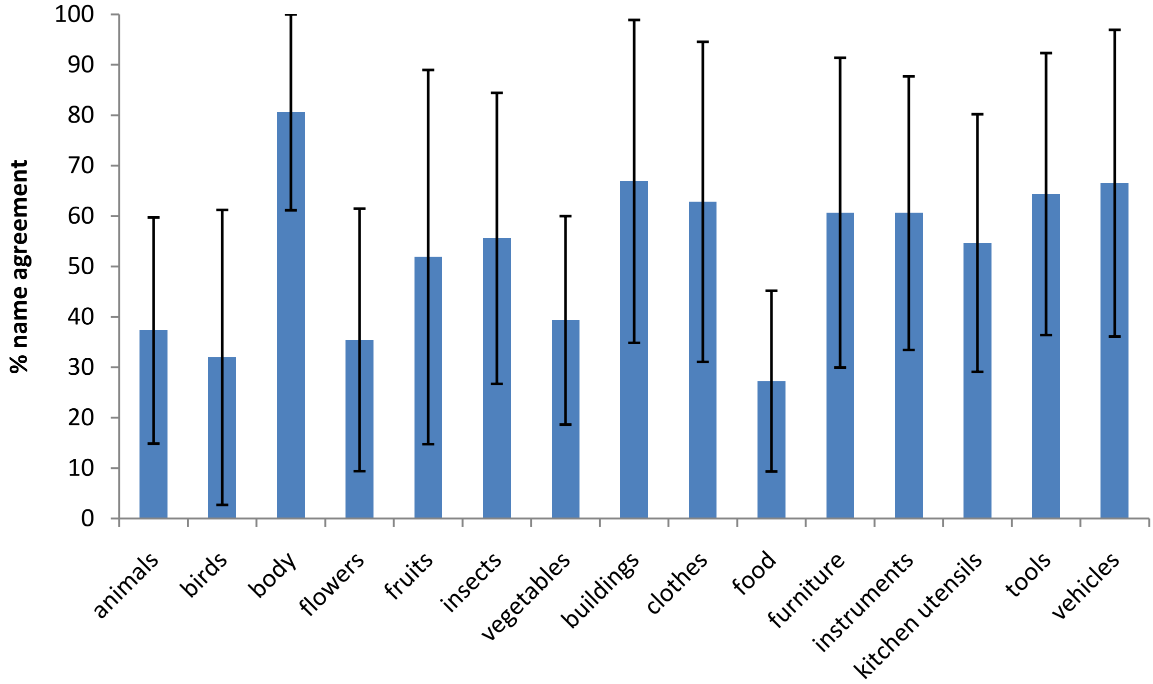
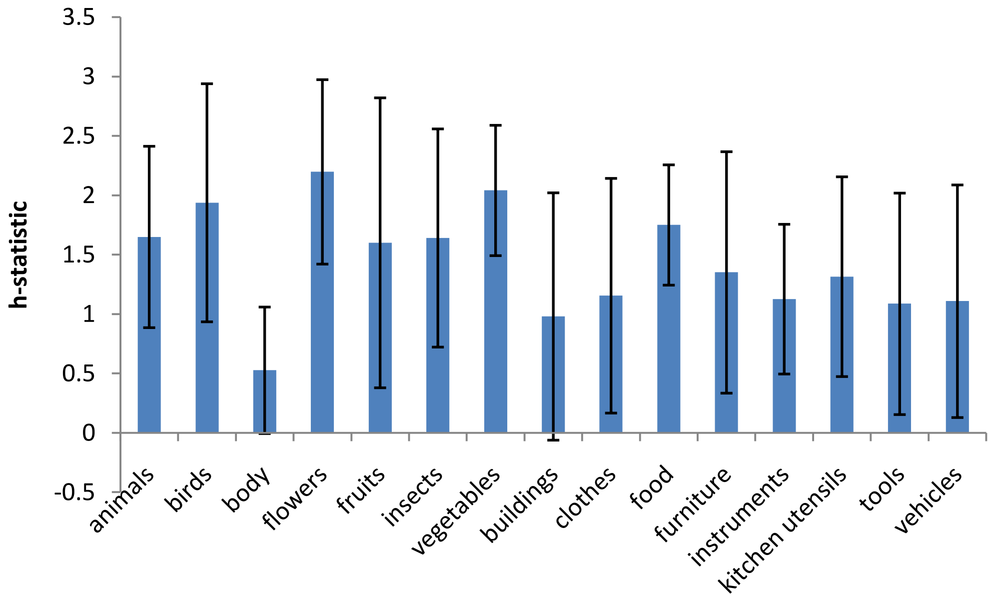


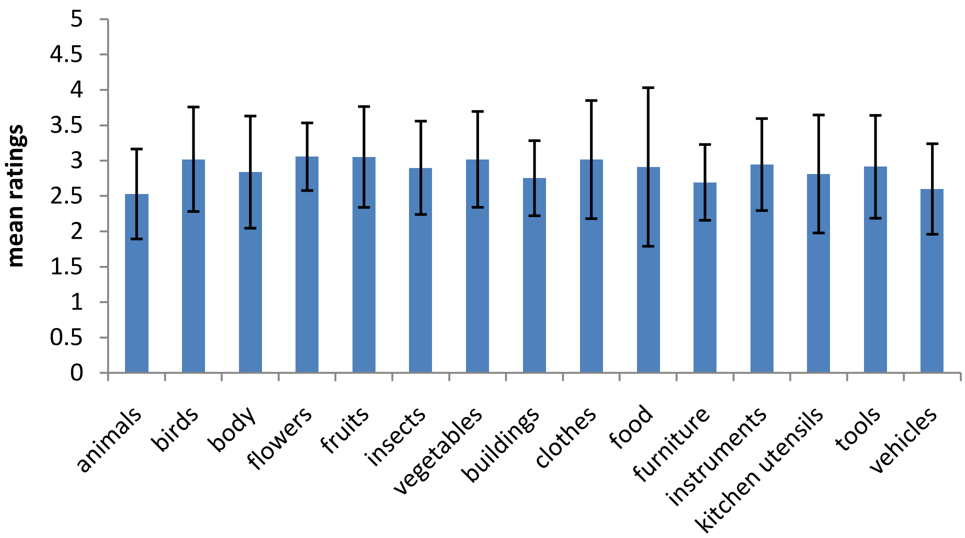
Figure 4.14 *H* statistic across subcategory for the line-drawn items



Visual Complexity

Ratings of visual complexity were obtained for each item. These are presented in Appendix E. Analyses showed that visual complexity did not differ significantly across subcategory (F (14, 146) =.51, p=0.92). Indeed, there is very little variance in the mean visual complexity values attributed to each subcategory (see figure 4.15).

Figure 4.15 Mean ratings of visual complexity across subcategory for the line-drawn items



The summary statistics for all ratings of the line-drawn images are provided in table 4.7. In addition, we also provide the findings of a Pearson's correlation between naming and all variables (including word frequency and familiarity to name) in table 4.8. Picture naming correlated significantly with all variables, with the exception of visual complexity, colour diagnosticity, and age of acquisition. Of these, only age of acquisition is found to correlate with any other variables, specifically familiarity to name.

Table 4.7 Summary statistics for ratings of the line-drawn items

	$F_{(i)}$	*VC*	*AA*	*CD*	*H*	*NA %*
M	3.80	2.86	5.67	3.37	1.39	54.81
SD	0.65	0.69	1.74	0.67	0.94	30.51
Mdn.	3.78	2.93	6.08	3.29	1.38	53.70
Skew	-0.19	-0.14	-0.39	-0.14	0.06	0.09
Range	2.55	3.21	6.69	3.14	3.40	100.00
Min	2.33	1.36	1.85	1.57	0.00	1.85
Max	4.87	4.57	8.54	4.71	3.4	100.00
Q1	3.33	2.28	4.31	2.93	0.66	25.93
Q3	4.35	3.43	7.00	3.86	2.12	83.33

Note. $F_{(i)}$ = familiarity to image; VC= visual complexity; AA= Age of acquisition; CD= colour diagnosticity; *H*= *H* Statistic; NA%= percentage name agreement; *Ql* = 25th percentile;*Q3* = 75th percentile

Table 4.8 Correlation matrix for picture naming performance and item ratings for the line-drawn items.

	$F_{(i)}$	$F_{(n)}$	*VC*	*AA*	*WF(Lg)*	*CD*	*H*	*NA%*
Picture Naming	.60**	.62**	-.01	-.12	.45**	-.04	-.87**	.86**
$Fam_{(i)}$		.68**	.08	-.04	.42**	-.03	-.54**	.54**
$Fam_{(n)}$			.10	-.24**	.62**	.11	-.57**	.57**
Visual Complexity				-.03	-.03	.10	.01	-.02
Age of Acquisition					-.17*	-.03	.07	-.10
Word Frequency (Log)						.02	-.45**	.44**
Colour Diagnosticity							.04	- .08
H statistic								-.92**

Note. $F_{(i)}$ = familiarity to image; $F_{(n)}$ = familiarity to name; VC= visual complexity; AA= Age of acquisition; WF(Lg) = word frequency (log); CD= colour diagnosticity; *H*= *H* Statistic; NA%= percentage name agreement

* < 0.05 level (2-tailed); ** <0.001 level (2-tailed).

4.3.3 Comparison of the normative data obtained for the colour, greyscale, and line-drawn versions of the HIT

Analyses were carried out to assess the extent to which format might influence naming, and if so, to explore whether this differed across subcategory. All analyses were conducted by subjects (F_1), and by items (F_2). In addition, the *minF'* statistic (Clark, 1973) was also calculated. This treats subjects and items as random effects within a single ANOVA, and therefore allows the researcher to determine whether the combined effects of the subjects and items analyses are significant.

Though participants were matched across format for education (F=1.34; p=0.26) and sex (χ^2 (2, N=268) =0.02; p>0.05), age was found to differ significantly across the groups (Colour M = 35.64, Greyscale M = 45.24, Line M = 43.69; F=5.84, *p*=0.003). Moreover, there was found to be a significant positive correlation between age and the total number of items named correctly (r=0.34, p<0.001). Age was therefore covaried in all analyses carried out by subjects (F_1).

For the items (F_2) analyses, a number of nuisance variables were found to differ across subcategory, though this differed somewhat depending on whether the ratings were obtained for the colour, greyscale, or line-drawn versions of the corpus (see table 4.9). To control for this, all variables that were found to differ across subcategory were controlled in the by items analysis. Thus, of the ratings obtained for the colour items, age of acquisition, colour diagnosticity, percentage name agreement, visual complexity, and word frequency were covaried. For those obtained for the greyscale versions, percentage name agreement was covaried, and for the line-drawn versions, percentage name agreement and the *H* statistic were covaried. In addition, familiarity to name and word frequency were covaried.

Table 4.9 Analysis of ratings of nuisance variables across subcategory for all versions of the HIT

	F-Values		
	Colour	Greyscale	Line-drawn
Age of Acquisition	2.13*	1.06	1.16
Colour Diagnosticity	11.8***	1.15	1.43
Familiarity (image)	1.35	1.19	.52
H statistic	1.00	1.62	2.01**
Name Agreement	1.86*	2.25**	2.59**
Visual Complexity	5.33***	0.25	0.51
Familiarity (name)	2.79***		
Word Frequency	2.33**		

Note. The headings colour, greyscale, and line-drawn refer to the version of the images for which the ratings were obtained. *p<.05; **p<.01; ***p<.001

Does normative naming across subcategory interact with format?

A two-way ANOVA was conducted to assess whether format and subcategory were found to interact. Analyses revealed no main effect of format F_1 (2, 264) = 4.39; p=0.01; F_2 (1, 123) = 7.20; p=0.01; $minF'$(2, 380) =2.73, p=0.07[10], or of subcategory F_1 (14, 264) = 74.48; p<0.001; F_2 (14, 123) = 1.07; p=0.39; $minF'$(14, 127) =1.05, p=0.41, and no interaction between subcategory and format F_1 (14, 264) = 15.66; p<0.001; F_2 (14, 123) = 0.77; p=0.70; $minF'$(14, 135) =0.73, p=0.74. As, figures 4.16 and 4.17 show, the effect of format differs little between the subcategories included though, in general, participants perform better with the greyscale and colour images, particularly for subcategories from the living domain.

[10] Although both the by items and by subjects analyses revealed significant main effects, the *minF'*statistic was only found to approach significance. Therefore, the effect of format was treated as non-significant.

Figure 4.16 Comparison of normative naming performance across format and subcategories from the living domain

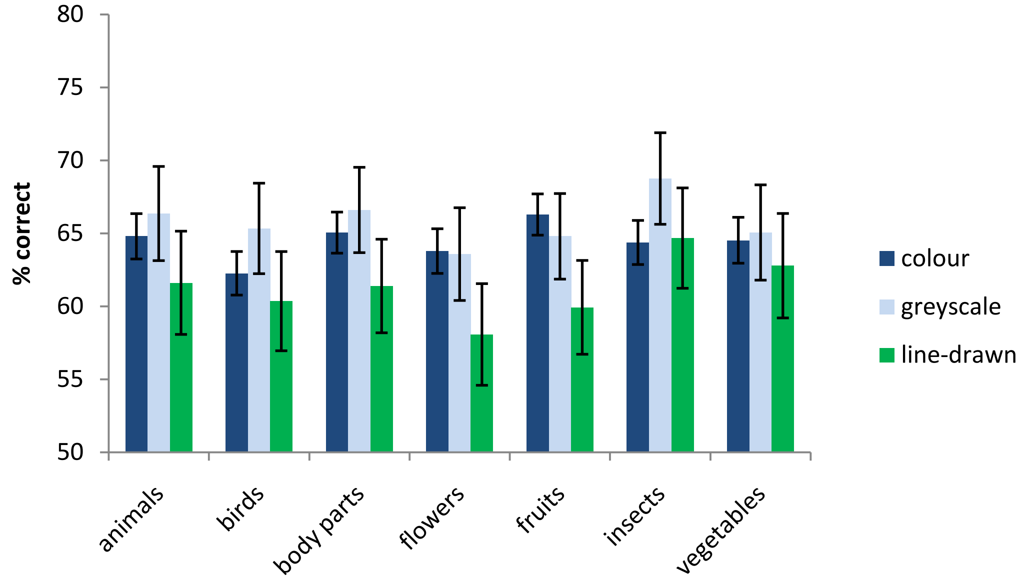
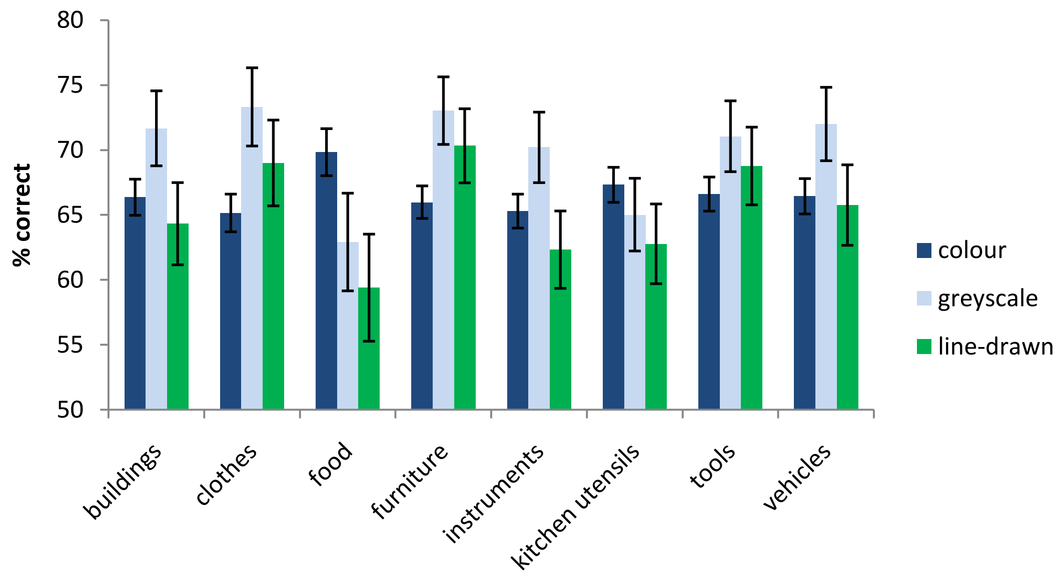


Figure 4.17 Comparison of normative naming performance across format and subcategories from the nonliving domain



Are the effects of nuisance variables on naming moderated by format?

Normative data for age of acquisition, familiarity to image, colour diagnosticity, name agreement, and visual complexity was obtained for all items, in each format. Familiarity to name and word frequency values, were applied to all formats as these variables relate to the name of the item rather than the image itself. To explore whether the predictive value of these variables differed across format, they were entered as predictors in regression analyses. In addition, as category has previously emerged as a significant predictor of naming (i.e. living v nonliving; Brousseau & Buchanan, 2004; Coppens & Frisinger, 2005; Filliter, McMullen, & Westwood, 2005;Gaffan & Heywood, 1993; Gerlach, 2001; Humphreys, Riddoch, & Quinlan, 1988; Låg, 2005; Laws, 2000; Laws & Neve, 1999; Laws & Hunter, 2006; Lloyd-Jones & Humphreys, 1997; Lloyd-Jones & Luckhurst, 2002; McKenna & Parry, 1994; Tippett et al., 1996), this was entered as a predictor in all analyses. Initial results revealed that across all analyses, the VIF for familiarity to image, familiarity to name, *H* statistic, percentage name agreement, and age of acquisition was high (the lowest being 7.45). Given that there were two measures of familiarity and name agreement, it was decided that those with the highest VIF statistic would be removed from subsequent analyses. Thus, familiarity to image, and percentage name agreement were removed. This reduced the VIF for age of acquisition, familiarity to name and *H* statistic to below 5 in all analyses. For the remaining variables, tolerance was at an acceptable level (lowest=0.21). The results are displayed in Table 4.10.

Table 4.10 Regression analysis to explore the extent to which nuisance variables were found to predict naming.

	Colour (r^2 = .86; p<0.001)		Greyscale (r^2=.80; p<0.001)		Line-drawn (r^2 =.79; p<0.001)	
	S-P	t	S-P	t	S-P	t
Category	-.52	-7.24***	-.40	-5.12***	-.23	-2.75**
Age of acquisition	-.35	-4.36***	-.09	-1.12	-.08	-.99
Colour diagnosticity	.30	3.76***	.08	.92	-.05	-.58
Familiarity (name)	.30	3.64***	.51	7.03***	.30	3.65***
H statistic	-.32	-10.19***	-.68	-11.04***	-.79	-15.13***
Visual complexity	.02	.49	-.06	-.79	-.04	-.44
Word frequency	.00	-.02	.02	-.27	-.01	-.30

Note: *p<0.05; **p<0.01; ***p<0.001

Regression analyses revealed a large degree of consistency across format, in relation to the variables that significantly predicted naming. Indeed, category, and name agreement as measured by the *H* statistic, and familiarity to name emerged as significant predictors of naming across all formats. In addition, age of acquisition and colour diagnosticity emerged as a significant predictor when items were presented in colour. Interestingly, colour diagnosticity emerged as a predictor only when the items were presented in colour.

Are sex, age, and years of education found to predict normative naming performance?

Previous studies have reported that normative naming may be influenced by certain participant variables including sex (e.g. Barbarotto, Laiacona, Macchi, & Capitani, 2002; Cameron, Wambaugh, & Mauszycki, 2008; Capitani, Laiacona, & Barbarotto, 1999; Laws, 2004; Marra, Ferraccioli, & Gainotti, 2007; McKenna & Parry, 1994), age (e.g. Barresi, Nicholas, Connor, Obler, & Albert, 2000; Farmer, 1990; Kavé, 2005; Kavé, Samuel-Enoch, & Adiv, 2009; LaBarge, Edwards, & Knesevich, 1986; Montgomery & Costa, 1983; Neils et al., 1995; Worrall, Yiu, Hickson, & Barnett, 1995), and years in education (e.g. Dordain, Nespoulos, Bordeau, & Lecours, 1983; Le Dorze & Durocher, 1992; Metz-Lutz et al., 1991; Nicholas, Brookshire, MacLennan, Schumacher, & Porrazzo, 1989). Regression analyses were therefore conducted to explore the extent to which these factors predicted naming across each image set. Across all analyses, VIF and tolerance were at an acceptable level (maximum VIF = 1.35; minimum tolerance = 0.76).As table 4.11 shows, sex, age, and years in education predict only a small proportion of the variance in overall naming. Of this, sex was not found to predict naming across any format, and years in education only predicted the naming of the colour items. By contrast, age was found to significantly predict naming of both the colour and greyscale image sets. Moreover, this was the only variable to correlate positively with naming across all formats (colour: r=0.31; p<0.01; greyscale: r=0.32; p<0.05; line-drawn: r=0.27; p<0.05).

Table 4.11 Regression analyses to determine the extent to which sex, age, and years in education predict normative naming.

	Colour (r^2 = .12; p<0.001)		Greyscale (r^2=.06; p=.08)		Line-drawn (r^2 =.09; p<0.05)	
	S-P	t	S-P	t	S-P	t
Sex	-.03	-.36	.08	.59	.26	1.9
Age	.36	4.73***	.29	2.36*	.24	1.75
Years in education	.17	2.06*	-.06	-.49	-.08	-.54

Note: *p<0.05; **p<0.01; ***p<0.001

4.4 DISCUSSION

The main aim of this investigation was to extend the scope of the HIT by developing and obtaining normative data for greyscale and line-drawn images, which are exact replicas of the original 147 items. As with the colour versions of the HIT, these images will be made freely available for experimental use, along with information pertaining to (i) the correct name for each item, and (ii) ratings of age of acquisition, colour diagnosticity, image familiarity, and name agreement as measured using the *H* statistic and percentage name agreement. A secondary aim was to compare the normative data obtained across the three formats, to determine whether format, as well as other stimulus and demographic variables, were found to influence naming.

4.4.1 Further development of the HIT; normative data for greyscale and line-drawn versions

One of the main reasons for developing greyscale and line-drawn versions of the HIT was to provide a corpus of items that allowed comparison of the effects of format across exactly the same items. At present, the only corpus that might allow researchers to do this is that compiled by Rossion and Pourtois (2004), which contains greyscale and coloured versions of the Snodgrass and Vanderwart (1980) corpus. However, as already discussed, healthy participants perform at ceiling with items from this set, which may mask any category effects exhibited by controls, potentially distorting interpretation of findings relating both to healthy individuals, and neurologically impaired patients (Fung, Chertkow, Murtha, Whatmough, Peloquin et al., 2001; Laws, Gale, Leeson & Crawford, 2005). For example, an apparent deficit for living things in patients could simply be an exaggeration of the normal trend if controls also find it more difficult to name living things. However if controls perform at ceiling, the normal trend would likely be hidden, which could lead to the reporting of potentially spurious category specific impairments. A major advantage of the HIT therefore, is that across all formats, performance approximates a normal distribution. Indeed the mean naming performance for the greyscale and line-drawn items was 68.63% and 63.85% correct respectively, which is well below ceiling.

In addition to naming performance data, ratings of familiarity to image, age of acquisition, visual complexity, and colour diagnosticity were obtained for all items. Though it was suspected that these ratings would be comparable to those obtained with the colour images, it is possible that ratings of visual complexity, colour diagnosticity, and familiarity to image in particular may differ to some extent across format, as these ratings were obtained in reference to the visual properties of the items. In addition, using the naming data, we were able to calculate the percentage name agreement and *H* value of each item. Interestingly, analyses revealed that these were the only variables to vary significantly across subcategory, indicating that the sets are well matched for the other variables for which ratings were obtained.

For both the greyscale and line-drawn versions of the images, analyses were carried out to explore whether sex differences emerged in naming across subcategory. In keeping with the analyses conducted for the colour versions (see chapter 3), these revealed significant interactions between sex and subcategory. Specifically, when presented with the greyscale items, females performed significantly better than males with flowers and vegetables, whereas males performed significantly better than females on tools, vehicles, and buildings. For the line drawings, though females performed better than males with vegetables and flowers, this did not reach significance. Males again outperformed females with tools, vehicles, and buildings, but in addition to this were also significantly better with insects, foods, and musical instruments. These findings are to a large extent consistent with previous studies that have found a normal male advantage for items from the nonliving domain (Coppens & Frisinger, 2005; Laws, 1999, 2000), specifically tools and vehicles (Barbarotto, Laiacona, Macchi, & Capitani, 2002). Moreover, they accord with evidence that within the living domain, females show an advantage for fruits and vegetables, whilst males are better with animals (McKenna & Parry, 1994). Nevertheless, it is unclear why sex differences occur for more subcategories when images are presented as line drawings, than when they are presented in greyscale or colour. One possible argument may be that as colour is thought to play a greater role in object recognition when shape information is degraded or insufficient for discrimination between items (Laws & Hunter, 2006; Price & Humphreys, 1989; Tanaka & Presnell, 1999), it may also be the case that colour is beneficial when the participant has limited knowledge about the shape of a particular object. Thus, if, as has been suggested, females are less familiar with tools (e.g. Laiacona et al., 1998; Moreno-Martínez, Laws, & Schulz, 2008), then females may find additional information relating to the appearance of the object of greater benefit to naming than males. Therefore the presence of this information may diminish any sex differences that might otherwise occur as a result of differences in familiarity. Though this is only a tentative suggestion requiring further research to explore the potential relationship between sex, familiarity, and format, it is interesting to note that the majority of studies that report a sex by category/subcategory interaction in normal participants use only line-drawn images (e.g. Barbarotto et al., 2002; Coppens & Frisinger, 2005; Laws, 1999, 2000). However, the male advantage for animals and female advantage for fruits and vegetables documented by McKenna and Parry (1994) was obtained using colour pictures.

4.4.2 A comparison of the normative data obtained across format

A comparison of naming performance across all formats revealed no main effect of format and no format by subcategory interaction. Though this is consistent with the findings of several early studies, which also found no effect of format (Biederman & Ju, 1988; Davidoff & Ostergaard, 1988; Humphreys & Price, 1989; Ostergaard & Davidoff, 1985), this differs somewhat from a number of studies demonstrating that object naming improves with the addition of surface detail (Brodie, Wallace & Sharrat, 1991, experiment 3; Davidoff & Ostergaard, 1988; Price and Humphreys, 1989; Rossion & Pourtois, 2004; Tanaka & Presnell, 1999; Williams & Tanaka, 2000; Wurm et al., 1993). Though it is not clear why the findings of this study differ from those of previous studies, one possibility is that performance is modulated by the distributed naming performance across the set. Specifically, given that colour is thought to be particularly important in the recognition of items for which shape information is not sufficient for discrimination (Laws & Hunter, 2006; Price & Humphreys, 1989; Tanaka & Presnell, 1999), it is possible that this surface information is only useful in the recognition of low frequency items that are more difficult to name. By contrast, as participants are able to name high frequency items with relative ease, colour and texture information does not play a significant role in object recognition. Thus, given that each subcategory of items contains a range of low-high frequency items, it is possible that any effect of format may be masked. Nonetheless, this does not explain why overall naming accuracy was higher for the greyscale images (68.36%) than for the colour images (65.57%), as previous research findings would suggest that performance should improve linearly with the addition of surface information (Humphrey et al., 1994).

Regression analyses were conducted to explore the extent to which other stimulus factors might influence naming. Category (i.e. living/nonliving) was also included as a predictor in this analysis as previous studies have shown that the naming performance of healthy controls may differ depending upon whether items are from the living or nonliving domain (Brousseau & Buchanan, 2004; Coppens & Frisinger, 2005; Filliter, McMullen, & Westwood, 2005;Gaffan & Heywood, 1993; Gerlach, 2001; Humphreys, Riddoch, & Quinlan, 1988; Låg, 2005; Laws, 2000; Laws & Neve, 1999; Laws & Hunter, 2006;Lloyd-Jones & Humphreys, 1997; Lloyd-Jones & Luckhurst, 2002; McKenna & Parry, 1994; Tippett et al., 1996). In accordance with these findings, category emerged as a significant predictor of naming across all formats. In addition, familiarity and name agreement also emerged as significant predictors across all formats. This is in keeping with previous studies that have demonstrated that these factors significantly influence naming (Albanese, Capitani, Barbarotto, & Laiacona, 2000; Brown & Watson, 1987; Funnell & Sheridan, 1992; Gernsbacher, 1984; Gilhooly & Gilhooly, 1979; Gilhooly & Logie, 1981; Hodgson & Ellis, 1998; Lachman, Schaffer, & Hennrikus, 1974; Mitchell, 1989; Paivio, Clark, Digdon & Bons, 1989; Vitkovitch & Tyrell, 1995). Colour diagnosticity was found to predict naming of the colour images, but not the greyscale or line-drawn items. In this instance, it is possible that this is an artefact of having provided ratings to the colour, greyscale, or line-drawn versions of the items. Indeed, if asked to rate the colour diagnosticity of the colour images, the salience of the colour may be somewhat enhanced (relative to providing the same ratings for the greyscale/line-drawn images). Therefore, the ratings of colour diagnosticity obtained for the colour items may more accurately reflect the extent to which the item is associated with a particular colour, thus heightening the predictive power of this variable.

Interestingly, age of acquisition, which has previously emerged as a powerful predictor of naming (Brown & Watson, 1987; Coltheart, Laxon, & Keating, 1988; Frederiksen & Kroll, 1976; Gilhooly & Logie, 1982; Humphreys, Riddoch, & Quinlan, 1988; Monsell, Doyle, & Haggard, 1989; Oldfield & Wingfield, 1965), was only found to predict naming of the colour items. Given that the VIF statistics were low, it is unlikely that the failure of age of acquisition to predict naming is a result of collinearity. Rather, it is possible that as many of the items featured in the corpus were low frequency, low familiarity items, a large proportion of items may not have been learned until later in life. Taken in conjunction with the fact that the latest age at which participants could report acquiring the name of an item was 13+ years of age, if this were so, then it is likely that there is a great degree of variance in the items which were given the highest age of acquisition rating. This may therefore limit the extent to which age of acquisition is found to predict naming.

A second regression analysis was also conducted to explore the influence of participant factors on naming. Age was the only variable to significantly predict naming of both the colour and greyscale items, while education was also found to predict naming of the colour items. None of the participant factors included in this analysis predicted the naming of the line-drawn items. Both education (Dordain et al., 1983; Le Dorze & Durocher, 1992; Nicholas et al., 1989), and age (Au et al., 1995; Barresi, Nicholas, Connor, Obler, & Albert, 2000; Farmer, 1990; Ivnik, Malec, Smith, Tangalos, & Peterson, 1996; Kavé, 2005; Kavé et al., 2009; LaBarge, Edwards, & Knesevich, 1986; Montgomery & Costa, 1983; Neils et al., 1995; Ross, Lichtenberg, & Christensen, 1995; Tombaugh & Hubley, 1997; Worrall, Yiu, Hickson, & Barnett, 1995) have previously been shown to influence object naming. Concerning the effects of age, there is however some discrepancy as to how this influences naming, with some studies reporting a negative effect of age (Au et al., 1995; Barresi et al., 2000; Ivnik et al., 1996; Kavé, 2005; Kavé et al., 2009; Neils et al., 1995; Edwards, & Knesevich, 1986; Montgomery & Costa, 1983; Ross, Lichtenberg, & Christensen, 1995; Tombaugh & Hubley, 1997; Worrall, Yiu, Hickson, & Barnett, 1995), while others report that naming improves as a result of age (Farmer, 1990; Schmitter-Edgecombe, Vesneski, & Jones, 2000). The current study supported the latter finding in that performance was found to improve with age.

There are a number of possible explanations for the inconsistent findings relating to the effects of age. A comprehensive review of 25 picture-naming studies by Goulet and colleagues (Goulet, Ska, & Kahn, 1994) noted that studies differed greatly on variables such as health, sex, and education, and that the statistical approaches employed by many of the studies were problematic, all of which might account for the discrepancy among findings. In addition, a recent study carried out by Schmitter-Edgecombe, Vesneski, and Jones (2000) demonstrated that the effect of age may relate to the use of specific items. Using the Boston Naming Test (BNT; Kaplan, Goodglass, & Weintraub, 1976) to explore naming in young and older adults, they documented better performance in the older adult group. Nonetheless, closer examination revealed that of the BNT items, there were four (yoke, trellis, palette and abacus) with which the older adults appeared to be more familiar, with 68% of the older adult group correctly identifying these items compared with only 28% of younger adults. When these items were removed, there was no difference in performance across the two groups. This finding is consistent with that of previous research demonstrating that whilst older adults performed significantly better than younger adults when shown objects that were 50-70 years old, the opposite pattern of performance was observed when participants viewed contemporary items (Poon & Fozard, 1978). Both studies therefore suggest than better performance with age may be attributed to cohort effects.

Although the positive correlation between naming and age reported here may relate to specific items in the corpus, this seems unlikely. Indeed, when divided by age group based on the 25th and 75th percentiles, the oldest group of participants were found to outperform the younger groups on nine out of fifteen subcategories (specifically, flowers, birds, vegetables, clothes, furniture, tools, vehicles, vehicles, buildings and musical instruments). Moreover, if certain subcategories were represented more by ‘old-fashioned’ items, we might expect these subcategories to have lower word frequency values, as these items would not commonly feature in contemporary language. This is more likely to be the case given that ratings of word frequency were based on the number of hits received when each item was entered into an internet search engine, thus providing a very up-to-date indication of the word frequency of each item. Nevertheless, as the analysis of word frequency in chapter 3 shows, when body parts and kitchen utensils were removed (which had the highest and lowest word frequency respectively), there was no significant differences in word frequency across subcategory. Thus, the relationship between age and naming appears to be a genuine phenomenon, providing further support to those studies that have found that picture-naming performance improves with age (Farmer, 1990; Schmitter-Edgecombe, Vesneski, & Jones, 2000).

Although age and education were found to influence naming, it is worth noting that sex did not emerge as a significant predictor. This is somewhat at odds with a number of studies that have shown that sex interacts with subcategory (e.g. Barbarotto, Laiacona, Macchi, & Capitani, 2002; Cameron, Wambaugh, & Mauszycki, 2008; Capitani, Laiacona, & Barbarotto, 1999; Laws, 2004; Marra, Ferraccioli, & Gainotti, 2007; McKenna & Parry, 1994). Nonetheless, in many of these studies the effect of sex is restricted to certain subcategories. For instance, a number of studies have shown that males outperform females when presented with tools, while females perform better with fruits and vegetables (Cameron, Wambaugh, & Mauszycki, 2008; Capitani, Laiacona, & Barbarotto, 1999; Laws, 2004). Based on these findings, it is unlikely that sex would emerge as a significant predictor of naming, as it would be predicted that any effects of sex would be restricted to only a small proportion of subcategories included in the analysis.

In summary, the current study provides an extension to the HIT corpus through the development of greyscale and line-drawn versions of all 147 items of the HIT, that are exact replicas of the original colour items. Moreover, further normative data is provided, specific to the greyscale and line-drawn items. Comparison of performance across the three image sets reveals little difference in regard to the effects of format, and also in relation to those variables that are found to predict naming performance across each format. Concerning the influence of stimulus factors such as familiarity, age of acquisition and word frequency for example, that these vary little across subcategory and across format, would make it relatively easy, for matched subsets of items to be assembled for research purposes.

Chapter 5. The influence of Format, Category, and Naming Difficulty on Naming Accuracy and Latencies in Healthy Controls.

5.1 INTRODUCTION

To accurately understand and interpret category specific impairments in neurologically impaired patients, it is necessary to know how neurologically intact participants perform on the same types of tasks. However, little has been done to establish the 'normal' tendency. Rather, researchers have relied on the use of within-group comparisons (Laws, Adlington, Gale, Moreno-Martinez & Sartori, 2007) with as few as one in five studies of category specific impairments comparing patients to controls (Laws, 2005). Given the prevailing view that the majority of patients exhibit a deficit for living things (Basso, Capitani, & Laiacona, 1988; DeRenzi & Lucchelli, 1994; Forde, Francis, Ridoch, Rumiati, & Humphreys, 1997; Sartori & Job, 1988; Sheridan & Humphreys, 1993; Silveri & Gainotti, 1988; Warrington & Shallice, 1984), it has been assumed that neurologically intact participants should be less efficient at naming living things. Whilst there is some support for this notion (Coppens & Frisinger, 2005; Gaffan & Heywood, 1993; Humphreys, Riddoch, & Quinlan, 1988; Lloyd-Jones & Humphreys, 1997), several studies have reported that controls are actually more accurate and quicker to name items from the living thing domain (Brousseau & Buchanan, 2004; Filliter, McMullen, & Westwood, 2005; Gerlach, 2001; Låg, 2005; Laws, 2000; Laws & Neve, 1999; Laws & Hunter, 2006; Lloyd-Jones & Luckhurst, 2002; McKenna & Parry, 1994; Tippett, Grossman, & Farah, 1996).

To account for this apparent discrepancy in the performance of healthy participants, several explanations have been put forward that relate to the properties of the images used. One such account, suggests that the failure to control for the effects of nuisance variables such as familiarity, and visual complexity (c.f., Funnell & Sheridan, 1992; Stewart, Parkin, & Hunkin, 1992) might inadvertently disadvantage the naming of items from a particular domain of knowledge. Indeed, a number of studies in which the effects of familiarity and visual complexity were not accounted for, have reported a disadvantage in the speed (Humphreys, Riddoch & Quinlan, 1988; Lloyd-Jones & Humphreys, 1997) and accuracy (Gaffan & Heywood, 1993) with which healthy participants recognise living things. By contrast, healthy participants purportedly exhibit the opposite trend when items are matched across category on these variables (Brousseau & Buchanan, 2004; Filliter, McMullen & Westwood, 2005; Gerlach, 2001; Laws, 2000; Laws & Neve, 1999; Låg, 2005; Lloyd-Jones & Luckhurst, 2002; McKenna & Parry, 1994).

Nevertheless, it is possible that the living thing advantage reported in studies that have controlled the effects of nuisance variables is due to other extraneous factors. Because of the high familiarity of the items commonly used in category specific research, typically images taken from the Snodgrass & Vanderwart corpus (Snodgrass & Vanderwart, 1980), healthy participants often perform at or near ceiling. As this may mask differences in performance across category, several authors have introduced time constraints to increase task difficulty. For example, using either a speeded naming experimental paradigm (Brousseau & Buchanan, 2004; Tippett et al., 1996), or a speeded presentation paradigm (Låg, 2005; Laws, 2000; Laws & Neve, 1999), researchers have reported a *normal* disadvantage for nonliving things. However, it has been argued that degrading viewing conditions in this way may change the demands of the task. Laws and Neve (1999) conjectured that using rapidly presented stimuli might disadvantage the recognition of low structural similarity items (i.e. nonliving things). Similarly, Gerlach (2001) suggested that degraded viewing conditions favours the processing of low spatial frequency components or global features, over that of high spatial frequency components or local features (Kitterle & Christman, 1991; Sergent, 1983). Therefore, in accordance with the visual crowding hypothesis (see chapter 1), the high structural similarity attributed to living things would mean that the processing of global features is likely to reveal more about living things than nonliving things, creating a living thing advantage. Though there is some support for this suggestion (Gerlach, 2001; Låg, 2005; Laws & Neve, 1999), several studies have reported contradictory findings. For example, Laws and Hunter (2006) found a living thing advantage in healthy participants even when stimuli were presented for a longer duration (1000ms). Similarly, under normal viewing conditions Filliter, McMullen and Westwood (2005) reported that healthy participants performed better with living thing items on a word-picture verification task.

Whilst the extent to which the manipulation of task demands may preferentially influence the processing of living things remains to be seen, it is evident that attempting to avoid ceiling effects in this way can potentially introduce confounding factors. As such, a number of researchers have suggested that a more reasonable solution may be to include low frequency stimuli as a means to increase task difficulty whilst keeping items matched for important nuisance variables (Coppens & Frisinger, 2005; Garrard et al., 2001; Whatmough et al., 2003). Using this approach, Coppens and Frisinger (2005) reported an advantage for nonliving things in healthy elderly participants, whilst no category effects were exhibited by a younger sample. This therefore lends support to the notion that previous reports of an advantage for living things may be attributed to the demands of the task.

To date, the majority of studies of category effects in both neurologically impaired and intact individuals have employed items from the Snodgrass and Vanderwart corpus (Snodgrass & Vanderwart, 1980). This corpus features 260 line drawings of everyday items from a range of living and nonliving subcategories, with norms for familiarity, name agreement, image agreement, and visual complexity. In recent years, it has been suggested that further to the ceiling effects typically associated with this corpus, the fact that these items are only presented as line drawings may also be problematic for research. As line drawings, the Snodgrass and Vanderwart (1980) corpus lack information relating to luminance, texture, and colour, all of which may inform object recognition (Regan, 2000). Moreover, research suggests that the extent to which these surface details inform object recognition is largely dependent on the properties of the object (Humphrey, Goodale, Jakobson & Servos, 1994; Price & Humphreys, 1989; Tanaka & Presnell, 1999; Wurm et al., 1993). For instance, the role of colour in particular interacts with the amount of shape information available. Thus, colour is more important for the recognition of objects that are degraded (Tanaka & Presnell, 1999), and for differentiating between objects with high structural similarity (Price & Humphreys, 1989; Wurm et al., 1993). As previously mentioned, proponents of the visual crowding hypothesis suggest that members of living thing categories are typically more structurally similar than nonliving things (e.g. animals; horse, donkey, zebra; compared to vehicles; car, bus, motorbike etc.). As such, the naming of living thing items by healthy participants may automatically be disadvantaged by the absence of colour from the Snodgrass and Vanderwart (1980) images.

In a similar vein, evidence suggests that the influence of colour on object recognition is modulated by the colour diagnosticity of the object presented; that is, how strongly a particular object is associated with a colour (Humphrey, Goodale, Jakobson & Servos, 1994; Tanaka & Presnell, 1999). For example, a ‘lemon’ may be said to have high colour diagnosticity, as it is strongly associated with the colour ‘yellow’. Conversely, a ‘chair’ has low colour diagnosticity, as it is not associated with a characteristic colour. Importantly, living things typically have higher colour diagnosticity than nonliving things, therefore the recognition of living things may again be at a disadvantage in picture naming tasks when line drawings are used.

Several studies have been conducted to explore the extent to which category effects observed in healthy participants may be an artefact of the use of line drawings. Rossion and Pourtois (2004) compared the reaction times and name agreement of healthy participants across category, presenting all participants with the original Snodgrass and Vanderwart (1980) items, as well as colour and greyscale versions of these items. They found colour improved the recognition of all objects (both living and nonliving) under normal viewing conditions, though this advantage was more evident for objects such as fruits and vegetables that are highly structurally similar and have high diagnosticity values. In contrast, a more recent study by Laws and Hunter (2006), reported that colour was advantageous for the naming of both living and nonliving things under normal viewing conditions.

In light of the foregoing, it is apparent that further research is needed to establish the ‘normal tendency’ for category naming in healthy participants, and also the extent to which colour may influence the naming of living and nonliving things. Furthermore, given the confounding effects of nuisance variables and ceiling level performance on the interpretation of category effects, it is necessary to control for these factors in this research. Concerning the latter, as altering the experimental paradigm to prevent ceiling effects may introduce further confounds, this study used items derived from the *Hatfield Image Test* (HIT: Adlington, Laws & Gale, 2009), a novel corpus of

147 colour images with norms for familiarity, age of acquisition, word frequency, name agreement, and visual complexity. This includes items of graded naming difficulty, thus permitting the selection of items on which performance is below ceiling. Line-drawn versions of these images (chapter 4), were also employed in this investigation. The aims of this study were to establish whether healthy participants are more accurate and faster to name living things or nonliving things when potential confounds are accounted for, and whether the presence of colour is found to influence naming.

5.2 METHOD

5.2.1 Participants

Forty participants[11] (20 females and 20 males; mean age = 32.47 years; SD = 16.33) took part in this study. All were native English speaking and had normal or corrected-to-normal vision. None of the participants had cognitive or perceptual impairments. Participants were pseudo-randomly allocated to the colour or line-drawn condition, the only stipulation being that equal numbers of males and females participated in each condition. Thus, 20 participants (10 females and 10 males; mean age =33.65 years; SD = 18.27) were shown colour versions of the images, whilst the other 20 (10 females and 10 males; mean age =31.3 years; SD =14.52) were shown line-drawn versions. Participants were matched across condition for age and years in education (see table 5.1).

Table 5.1 Comparison of age and years in education across condition (colour and line-drawn).

	Colour **Mean(SD)**	**Line Drawings** **Mean (SD)**	
Age	33.65 (18.27)	31.3 (14.52)	F<1
Years in Education	14.85 (2.13)	14.85 (2.03)	F<1

[11] The individuals who participated in this investigation did not take part in any other study detailed in this thesis.

5.2.2Materials

For the purpose of this investigation, 105 items were selected from the HIT corpus: 48 living things (8 animal, 7 bird, 5 body part, 7 flower, 7 fruit, 7 insect, and 7 vegetable items) and 57 nonliving things (7 building, 7 clothes, 5 food, 7 furniture, 8 kitchen utensil, 9 musical instrument, 7 tool, and 7 vehicle items). Based on the normative data obtained by Adlington et al., (2009), these items were selected as they were named correctly by less than 90% of the sample, and were matched across category for familiarity to image and name, age of acquisition, word frequency, name agreement, and visual complexity. For the purpose of this experiment, line-drawn versions of these images were used also. All images were presented at 283x283 pixels on a laptop computer using the Testbed (version 1.0) software package, a bespoke picture presentation program. Reaction times were recorded using the SV1 Luminar voice key voice-activated reaction time software.

5.2.3 Design and Procedure

In all experiments, the *105* images (either colour/line-drawn dependent on condition) were presented in random succession using a laptop computer and the Testbed (Version 1.0) software package. Each image was preceded by a fixation cross (+) for 500ms. The image was then presented on screen and remained visible until the participant responded. Participants were asked to name each image as briefly and unambiguously as possible, by stating only one name though the name itself could consist of more than one word. Participants were asked to say ‘don’t know’, if the image was unknown to them. Their responses were recorded verbatim by the experimenter. Reaction times were recorded using voice activated software.

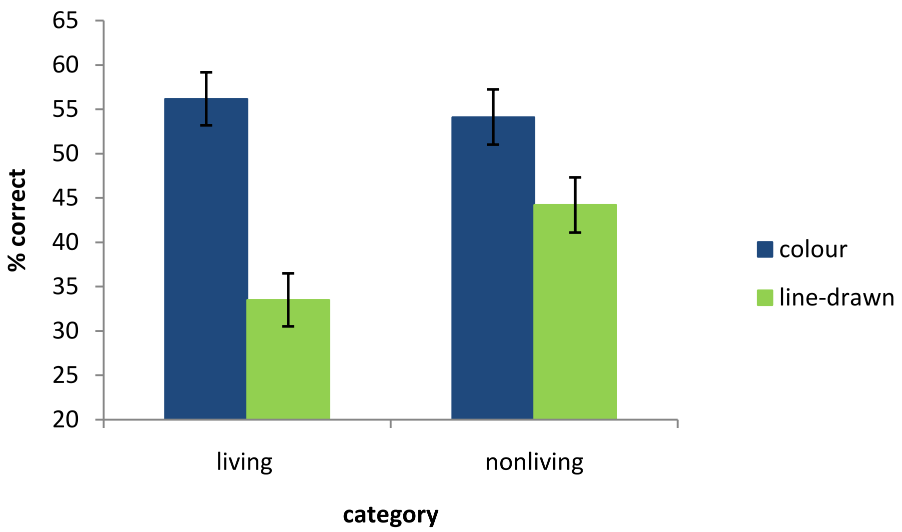
5.3 RESULTS

In accordance with Clark (1973), all analyses were conducted across both participants (F_1) and items (F_2). By convention, the F-values obtained with participants as the random factor are referred to by F_1, and items as the random factor as F_2. We also calculated the *minF'*statistic (Clark, 1973), which treats subject and items as random effects in a single ANOVA.

5.3.1 Naming Accuracy Analyses

A two-way ANOVA revealed a significant effect of image format (F_1 (1, 38) =19.42; *p*<0.001; F_2 (1, 97) = 78.64; *p*<0.001; *minF'* (1, 58) 15.57, *p*<0.001) with naming accuracy being higher for the colour (*M* = 55.14) than the line-drawn images (*M*= 38.84). By contrast, there was no effect of category (F_1 (1, 38) =3.73; *p*=0.06; F_2 (1, 97) =0.91; *p*=0.34; *minF'* (1, 130) <1) though participants showed better naming of nonliving (*M*= 49.15) than living things (*M*= 44.78). Format and category were found to interact (F_1 (1, 38) =8.13; *p*=0.007; F_2 (1, 97) = 12.17; *p*=0.001; *minF'* (1, 90) 4.87, *p*=0.03).

Figure 5.1 Naming accuracy across format and category



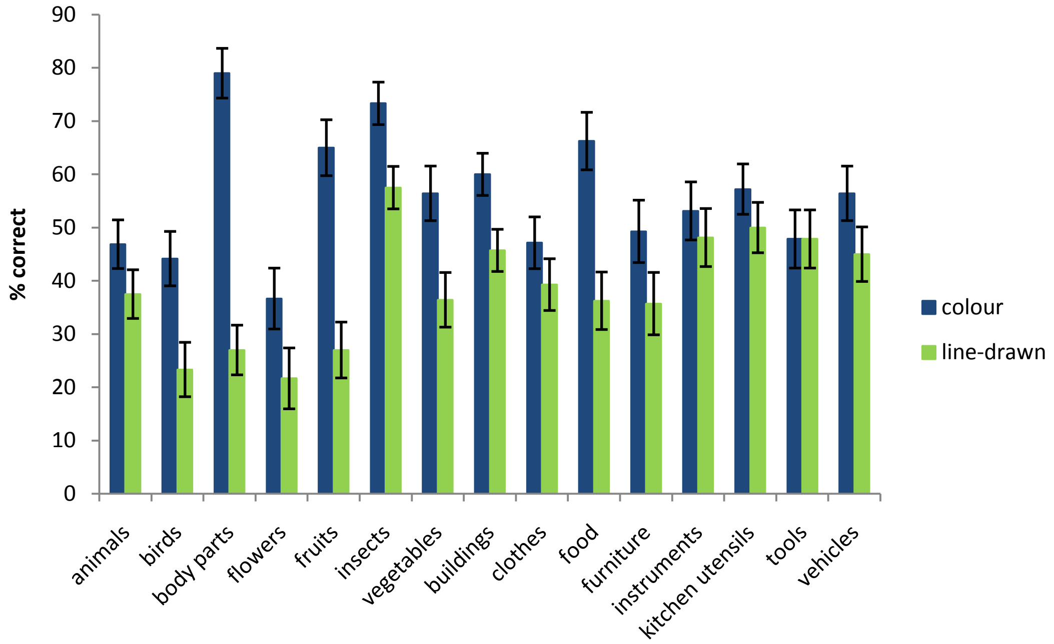
Note: error bars denote standard error

Figure 5.1 reveals that participants are more accurate with colour images, but also that the effect of format differs across category, with living things benefiting more from the addition of colour, than nonliving things. Moreover, the direction of the category advantage appears to be dependent upon format, with living things named more accurately than nonliving things when the items are presented in colour, whilst the reverse is true when the items are presented as line drawings. Nevertheless, the effect of category is only significant when items are presented as line drawings ($F\ (1, 98) = 5.93$; $p<0.05$).

The analysis described above was also conducted as a three-way ANOVA with sex as a factor. However, there was no main effect of sex ($F_1\ (1, 36) = 0.01$; $p=0.93$; $F_2\ (1, 97) = 0.06$; $p=0.80$; *minF'* (1, 49) <1), and no interaction between sex and format ($F_1\ (1, 36) =0.14$; $p=0.71$; $F_2\ (1, 97) = 1.16$; $p=0.29$; *minF'* (1, 45) <1), or between sex and category ($F_1\ (1, 36) =0.69$; $p=0.41$; $F_2\ (1, 97) = 1.19$; $p=0.28$; *minF'* (1, 80) <1).

Analyses were also conducted to explore differences in subcategory naming. A two-way ANOVA revealed a significant effect of format ($F_1\ (1, 38) =23.28$; $p<0.001$; $F_2\ (1, 90) = 103.32$; $p<0.001$; *minF'* (1, 56) 18.99, $p<0.001$), though there was no effect of subcategory ($F_1\ (14, 38) =7.37$; $p<0.001$; $F_2\ (14, 90) = 1.06$; $p=0.40$; *minF'* (14, 112) <1). A significant interaction was found between format and subcategory ($F_1\ (14, 38) =4.53$; $p<0.001$; $F_2\ (14, 90) = 3.56$; $p<0.001$; *minF'* (14, 117) 1.99, $p=0.02$).

Figure 5.2 Naming accuracy across format and subcategory



Note: error bars denote standard error

Figure 5.2 shows that colour appears to be more important for the recognition of living thing subcategories than for nonliving subcategories. Indeed, table 5.2 reveals that the subcategories of birds, body parts, fruits, and insects benefit significantly from the presence of colour. Interestingly, there is also a significant difference across format for the nonliving subcategories of buildings, foods, and kitchen utensils.

Table 5.2 Pairwise comparisons (colour-line-drawn) across subcategory

Subcategory	Colour Mean (SD) naming accuracy	Line-drawn Mean (SD) naming accuracy	colour – line-drawn (t-value)
Animals	46.88 (24.04)	37.5 (25.49)	1.49
Birds	38.57 (28.83)	20.14 (19.41)	3.73**
Body parts	79.00 (28.37)	27.00 (18.23)	5.76 **
Flowers	34.28 (29.36)	19.29 (16.94)	2.23
Fruits	47.14 (34.26)	20.71 (17.66)	3.16*
Insects	65.00 (30.55)	50.00 (26.93)	3.44*
Vegetables	56.43 (28.24)	36.43 (19.94)	2.01
Buildings	60.00 (36.74)	45.71 (24.57)	2.55*
Clothes	47.14 (24.13)	39.23 (20.49)	1.87
Food	68.00 (25.15)	31.00 (28.59)	4.23*
Furniture	49.29 (23.53)	35.71 (12.39)	1.97
Instruments	57.22 (22.52)	50.00 (23.98)	1.39
Kitchen utensils	53.13 (26.31)	48.13 (26.72)	5.29***
Tools	47.86 (21.19)	47.86 (24.13)	.00
Vehicles	56.43 (27.34)	45.00 (16.07)	1.49

*p<.05; **p<.01; ***p<.001

5.3.2 RT analyses

Prior to analysis, all response time for errors were removed. In addition, 6 items (elderberries, iris, papaya, falcon, samosa, and silverfish) were removed altogether as these were named correctly by less than 10% of participants in at least one condition[12] (i.e. colour/line-drawn). To ensure items remained matched across category for potentially confounding variables, a one-way ANOVA was carried out, the results of which can be seen in table 5.3.

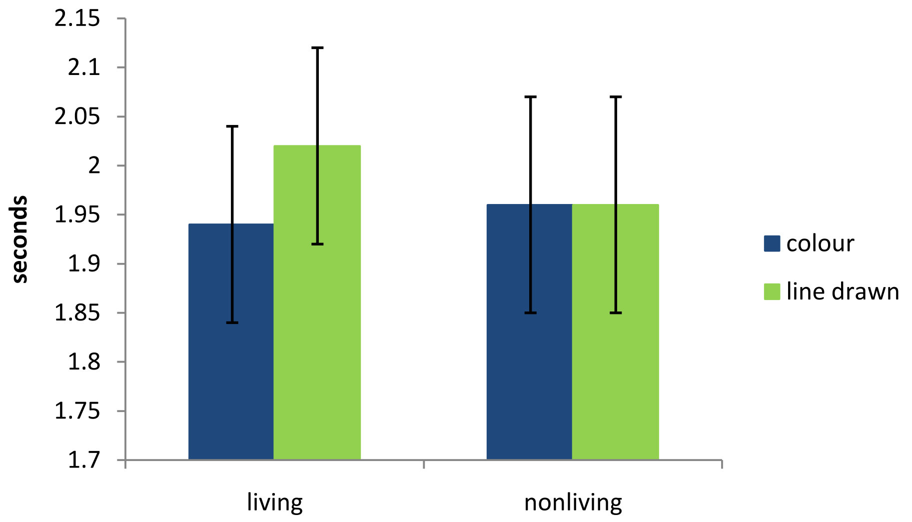
Table 5.3 Comparison of means (SD) of intrinsic variables, across living and nonliving things (df =1, 98)

	Living	Nonliving	ANOVA
Age of Acquisition	6.58 (1.23)	6.789 (.89)	F = 2.01, *p*=.16
Image Familiarity	3.45 (.55)	3.48 (.54)	F<1
Name Familiarity	3.12 (.84)	2.91 (.72)	F=1.93, *p*=.17
H statistic	1.29 (.70)	1.52 (.81)	F= 2.26, *p*=.14
Name Agreement	55.49 (23.41)	58.89 (20.67)	F<1
Visual Complexity	3.02 (.36)	2.97 (.52)	F<1
Word Frequency (log)	16.49 (1.83)	16.29 (1.57)	F<1

Using a two-way ANOVA, no main effect was found of format (F_1 (1, 38) =0.09; *p*=0.77; F_2 (1, 97) = 0.3; *p*=0.59; *minF'* (1, 62) <1), or of category (F_1 (1, 38) = 0.10; *p*=0.76; F_2 (1, 97) = 0.003; *p*=0.95; *minF'* (1, 97) <1). In addition, there was no interaction between format and category (F_1 (1, 38) =0.34; *p*=0.57; F_2 (1, 97) = 0.001; *p*=0.98; *minF'* (1, 97) <1).

[12] Owing to the high rate of naming error found using the HIT items, we subsequently re-ran the RT analyses excluding those items named by less than 20% participants in at least one of the conditions, specifically 25 items (therefore 31 in total). Items remained matched across category on all nuisance variables. As before, a two-way ANOVA, revealed no main effect of format (F_1 (1, 38) =0.87; *p*>0.05; F_2 (1, 72) = 0.01; *p*>0.05; *minF'* (1, 74) <1), or of category (F_1 (1, 38) = 110.57; *p*<0.001; F_2 (1, 72) = 0.02; *p*>0. 05; *minF'* (1, 72) <1). In addition, there was no interaction between format and category (F_1 (1, 38) =1.87; *p*>0.05; F_2 (1, 72) = 0.16; *p*>0.05; *minF'* (1, 84) <1).

Figure 5.3 Reaction times across format and category (number of items = 99)

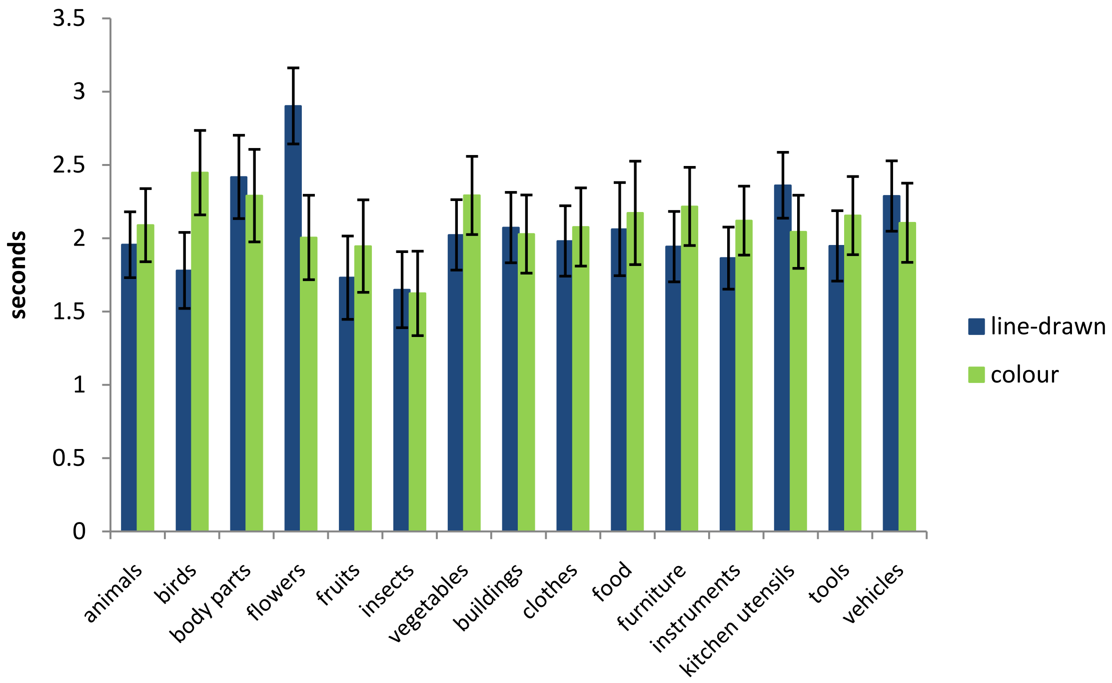


Note: error bars denote standard error

As before, the data was further analyzed to see whether an effect of sex emerged. However, there was no main effect of sex (F_1 (1, 36) = 0.19; *p*=0.66; F_2 (1, 97) = 4.83; *p*=0.03; *minF'* (1, 39) <1), no sex by format interaction (F_1 (1, 36) =0.19; *p*=0.66; F_2 (1, 97) = 4.09; *p*=0.05; *minF'* (1, 39) <1), and no sex by category interaction (F_1 (1, 36) = 0.001; *p*=0.97; F_2 (1, 97) = 0.91; *p*=0.34; *minF'* (1, 36) <1).

As for naming accuracy, analyses were conducted to explore differences in reaction time across subcategory. A two-way ANOVA showed no effect of format (F_1 (1, 17) =0.51; *p*=0.49; F_2 (1, 84) = 0.27; *p*=0.61; *minF'* (1, 82) <1) or of subcategory (F_1 (14, 17) =1.39; *p*=0.16; F_2 (14, 84) = 0.76; *p*=0.71; *minF'* (14, 81) <1), and no interaction between format and subcategory (F_1 (14, 17) =2.10; *p*=0.01; F_2 (14, 84) = 1.22; *p*=0.28; *minF'* (14, 79) <1). Figure 5.4 shows that there is generally little difference in the mean reaction times for items from each of the subcategories, with the only exception to this being the subcategory of flowers, which appears to be named more quickly as line drawings.

Figure 5.4 Mean reaction times across subcategory and format



Note: error bars denote standard error

5.3.3 Does Item Naming Difficulty influence Performance?

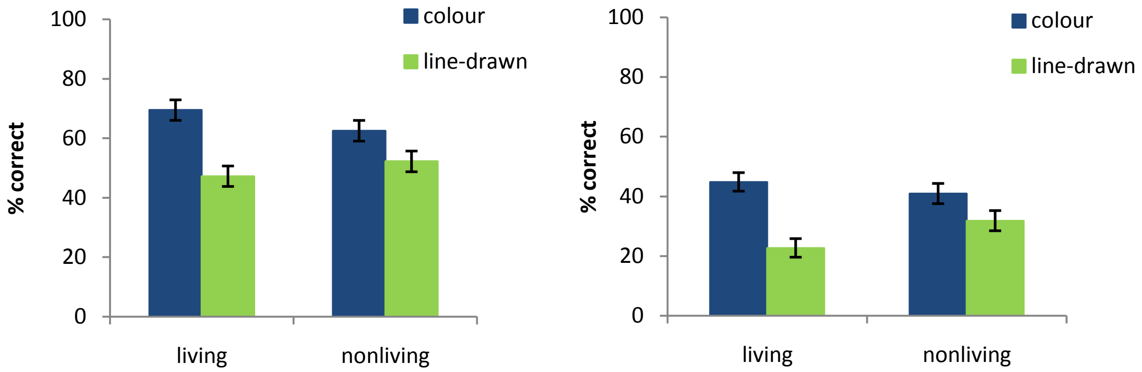
One issue that is apparent in the analysis of the data obtained here is that whilst the use of the HIT items reduces the emergence of ceiling effects, the by-product of this is an increased error rate, which might have some effect on the analysis of the data. In particular, concerning the RT data, the high error rate meant that some items were excluded, whilst others may have only been named correctly by a relatively small percentage of participants. As such, we reanalyzed both the naming and RT data across category, dividing the items into two subsets, those that were easy to name (named by 45% or more: M% correct = 76.0[SD = 16.6]; n=52; living = 18; nonliving = 34), and those that were difficult to name (named by fewer than 45%: M% correct = 40.2[SD = 21.4]; n=53; living = 30; nonliving = 23). Both the easy and difficult sets were matched across category (living vs. nonliving) on a number of potentially confounding variable (see Table 5.4; also see Appendix H for a list of items included in the easy and difficult subsets).

Table 5.4 Comparison of matching variables across category for the easy and difficult stimulus sets

	Easy Items (n=52)			**Difficult Items (n=53)**		
	Living *M(SD)*	Nonliving *M(SD)*	F values (df = 1, 51)	Living *M(SD)*	Nonliving *M(SD)*	F values (df = 1, 52)
Age of Acquisition	6.3 (1.4)	6.6 (0.8)	1.4, *p*=.3	6.9 (1.0)	7.3 (0.8)	1.9, *p*=.2
Familiarity	3.6 (0.6)	3.7 (0.4)	<1, *p*=.8	3.3 (0.5)	3.2 (0.6)	<1, *p*=.8
Name Agreement	60.4 (19.9)	58.8 (19.1)	<1, *p*=.8	39.0 (22.7)	39.8 (21.1)	<1, *p*=.9
Visual Complexity	3.0 (0.3)	3.0 (0.5)	<1, *p*=.9	3.0 (0.4)	2.8 (0.6)	3.0, *p*=.1
Word Frequency(log)	15.0 (1.8)	14.9 (1.8)	<1, *p*=.8	14.9 (1.8)	14.7 (1.8)	<1, *p*=.6

Analysis of the easy items revealed a significant effect of format (F_1 (1, 38) =17.89; *p*<0.001; F_2 (1, 49) = 37.97; *p*<0.001; *minF'* (1, 70) =12.16; *p*<0.001), but no effect of category (F_1 (1, 38) 0.11; *p*=0.75; F_2 (1, 49) =0.03; *p*=0.88; *minF'* (1, 72) <1). There was no interaction between format and category as indicated by the *minF'*, though this was approaching significance when analyzed by subjects, and was significant when analyzed by items (F_1 (1, 38) =3.87; *p*=0.06; F_2 (1, 49) = 4.75; *p*=0.03; *minF'* (1, 83) =2.13; *p*=0.15). The results obtained using the more difficult items mirrored those obtained with the easy items. Indeed, this revealed a main effect of format (F_1 (1, 38) =16.25; *p*<0.001; F_2 (1, 46) = 35.9; *p*<0.001; *minF'* (1, 69) =11.19; *p*<0.001), but no effect of category (F_1 (1, 38) =1.11; *p*=0.30; F_2 (1, 46) = 0.15, *p*=0.71; *minF'* (1, 58) <1). The interaction between format and category was again found to approach significance (F_1 (1, 38) =6.89; *p*=0.01; F_2 (1, 46) = 7.08; *p*=0.01; *minF'* (1, 83) =3.49; *p*=0.07). The findings obtained with both the easy and difficult image sets are therefore comparable with the overall pattern of naming performance reported earlier (see figure 5.5).

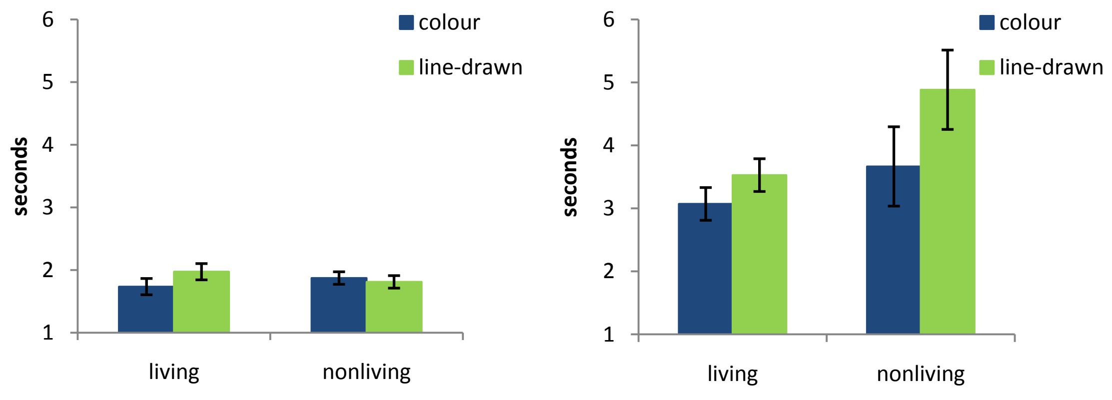
Figure 5.5 Comparison of naming accuracy across the easy (left) and difficult (right) image sets.



Note: error bars denote standard error

Consistent with the findings obtained relating to naming performance, the results obtained with the easy and difficult subsets of items pertaining to naming latencies were consistent with the overall pattern of performance. Specifically using the easy set of items, analyses failed to show a main effect of format (F_1 (1, 38) =0.38, p=0.54; F_2 (1, 49) = 0.24, p=0.63; *minF'* (1, 86) <1) or category (F_1 (1, 38) =0.02; p=0.88; F_2 (1, 49) = 0.18, p=0.68; *minF'* (9, 47) <1), and showed no interaction between format and category (F_1 (1, 38) =3.09; p=0.09; F_2 (1, 49) = 2.14; p=0.15; *minF'* (1, 87) = 1.26; p=0.26). Likewise, analyses of the difficult items revealed no main effect of format (F_1 (1, 38) =2.63; p=0.11; F_2 (1, 46) = 0.62, p=0.43; *minF'* (1, 66) <1) or of category (F_1 (1, 38) =4.86; p=0.03; F_2 (1, 46) = 1.39; p=0.25; *minF'* (1, 69) =1.08; p=0.3), and no interaction between format and category (F_1 (1, 38) =0.74; p=0.40; F_2 (1, 46) = 1.33; p=0.26; *minF'* (1, 73) <1).

Figure 5.6 Comparison of naming latencies across the easy (left) and difficult (right) image sets.



Note: error bars denote standard error

5.3.4 Predictors of Naming Accuracy and Latencies

A correlation matrix is shown in table 5.5. From this, it is apparent that most variables featured in this analysis correlate highly with one another, the exceptions being visual complexity, which only correlates with familiarity to image, and category, which correlates solely with naming accuracy for the line drawings.

Table 5.5 Correlations between nuisance variables, naming accuracy, and naming latency.

	Line RT	**Col. Acc**	**Line Acc**	**Category**	**AoA**	**CD**	**Fam (I)**	**H**	**VC**	**WF (log)**
Col. RT	.26**	-.37**	-.38**	.01	.26**	-.10	-.43**	.20*	-.04	-.00
Line RT		-.29**	-.31**	.00	.21*	-.17	-.30**	.20*	.01	-.15
Col. Acc			.70**	-.04	-.63**	.33**	.67**	-.58**	-.10	.27**
Line Acc				.24*	-.29**	.12	.47**	-.42**	-.04	.07
Category					.14	-.58**	.03	.15	-.07	-.06
AoA						-.25*	-.76**	.41**	.14	-.45**
CD							.22*	-.27**	.02	.09
Fam (I)								-.44**	-.24*	.24*
H									-.00	-.14
VC										.15

Note: Col. RT= colour naming latency; Line RT = line-drawn naming latencies; Col. Acc = colour naming accuracy; Line Acc. = Line-drawn naming accuracy; Category = living/nonliving; AoA= age of acquisition; CD = colour diagnosticity; Fam (I) = image familiarity; H = *H* statistic for name agreement; VC = visual complexity; WF (log) = log. Word frequency.

To assess the extent to which category was predictive of naming speed and accuracy, this was entered into a regression model, alongside those variables for which normative data is available for the HIT, specifically, age of acquisition, colour diagnosticity, familiarity to image, *H* statistic as a measure of name agreement, visual complexity and word frequency. Percentage name agreement was not included given that this is closely associated with naming accuracy (r= .85; p<0.01 for colour; r=.64; p<0.01 for line-drawn), and therefore would explain a large proportion of the variance, potentially masking the effects of the other predictors. Familiarity to name was not included in the analysis due to the high correlation noted between this and familiarity to image. Analyses were conducted for the set of items for the reduced set of images (i.e. with 6 items removed). Separate models were used to explore those factors predicting naming accuracy and naming latencies for the colour and line-drawn images. Table 5.6 shows that only name agreement (H statistic) and familiarity to image emerged as significant predictors of naming both for the colour and the line-drawn conditions. Category was also found to predict the naming of the line-drawn images, while colour diagnosticity predicted colour naming. By contrast, only familiarity emerged as a significant predictor of naming latencies in the colour condition. None of the variables entered into the model were found to predict naming latencies for the line-drawn images.

Table 5.6 Regression analyses to determine the extent to which nuisance variables may predict naming accuracy and accuracy latency

	RT line-drawn (r^2 = .05; p>0.05)		RT – colour (r^2=.16; p<0.01)		Naming – line-drawn (r^2 =.33; p<0.001)		Naming – colour (r^2=.57; p<0.001)	
	S-P	t	S-P	t	S-P	t	S-P	t
Category	-.06	-.60	.04	.35	.35	3.60***	.18	1.78
vis. Complexity	-.04	-.37	-.18	-1.74	.07	.66	-.01	-.05
Age of acquisition	-.08	-.74	-.08	-.71	.06	.61	-.18	-1.74
Colour diagnosticity	-.13	-1.20	.01	.11	.20	1.93	.25	2.42*
H statistic	.07	.62	.01	.08	-.31	-3.13**	-.41	-4.25***
Familiarity (image)	-.19	-1.88	-.36	-3.67***	.26	2.60**	.27	2.71**
Log frequency	-.10	-.94	.11	1.02	-.02	-.23	-.07	.70

Note. *p<0.05; **p<0.01; ***p<0.001

Hierarchical regression analyses were also run for the line and colour naming (latencies and accuracy) entering in block 1 (visual complexity, age of acquisition, colour diagnosticity, H statistic, familiarity (to image) and log frequency) followed in block 2 by category. These revealed that category had no significant impact on naming latencies for either line drawings or colour stimuli (while the nuisance variables accounted for 12% and 22% of variance). For accuracy, nuisance variables accounted for 29% and 59% of variance in naming; while category significantly accounted for 9% of variance for naming line drawings, but was nonsignificant for colour naming (accounting for <2%).

5.4 DISCUSSION

The main aim of this study was to explore whether healthy participants were more accurate and/or faster to name items from either the living or nonliving domain (after matching for potentially confounding factors). Additionally, we aimed to establish whether an effect of image format (i.e. colour/line-drawn) emerged, and if format interacts with semantic category. Analysis of the accuracy data revealed no significant effect of category, but a significant interaction between format and category whereby the recognition of living things benefitted more than nonliving things from the addition of colour. By contrast, analysis of the naming latency data failed to reveal any significant effects. All analyses were conducted across a matched set of 105 items, as well as across matched subsets of easy and difficult items, to determine whether the results obtained were an artifact of item naming difficulty. Nevertheless, the findings for both naming accuracy and latency were comparable to those obtained for the whole corpus, suggesting that it is unlikely that the use of low frequency items could account for findings.

Regarding the accuracy data initially, that an effect of category failed to emerge is somewhat inconsistent with previous studies of category-specificity in healthy controls that have shown both an advantage for living things (Brousseau & Buchanan, 2004; Filliter, McMullen, & Westwood, 2005; Gerlach, 2001; Låg, 2005; Laws, 2000; Laws & Neve, 1999; Laws & Hunter, 2006; Lloyd-Jones & Luckhurst, 2002; McKenna & Parry, 1994; Tippett et al., 1996), and for nonliving things (Coppens & Frisinger, 2005; Gaffan & Heywood, 1993; Humphreys, Riddoch, & Quinlan, 1988; Lloyd-Jones & Humphreys, 1997). Nevertheless, researchers have argued that lack of control over nuisance variables and the introduction of time constraints to prevent performance reaching ceiling, might account for the emergence of nonliving, and living thing advantages respectively. By contrast, the findings of Coppens and Frisinger (2005) are somewhat more in keeping with those of the present study. They employed a matched subset of low frequency items taken from the Snodgrass and Vanderwart (1980) corpus to explore normal naming in young, young elderly and old elderly adults. In using low frequency items, they were able to avoid the problem of ceiling effects without the need to introduce changes to task demands. Their findings revealed that whilst both groups of elderly participants showed an advantage for nonliving things, no category effect emerged in the young adults though they again showed a preference for nonliving things. This is therefore taken as evidence that while there may be some preference for nonliving things, it is only as a result of the degradation of semantic memory that occurs with normal aging, that a significant category effect might emerge. Though our study did not consider the impact of age on picture naming, the sample used had a mean age of 32.47 years, which is more similar to that of the young adults (22.4 years), than the young elderly (67.07 years) group employed by Coppens and Frisinger. As such, it is possible that the young age of the participants in this study may to some extent account for the lack of a category effect. Nevertheless, it is important to note that several studies documenting category effects in healthy controls have done so using young adults, typically university students (Albanese, 2007; Barbarotto, Laicona, & Capitani 2008; Låg, 2005; Laws & Gale, 2002; Laws & Hunter, 2006; Laws & Neve, 1999).

Though no overall effect of category emerged, post hoc analyses detected a significant category effect when items were presented as line drawings. When presented with the colour items, participants also appeared to perform better with nonliving things, though this failed to reach significance. Regression analyses revealed that for line and colour naming accuracy, name agreement and familiarity to image emerged as significant predictors, whilst category only emerged as a predictor for naming of the line drawings. Moreover, hierarchical regression analyses showed that category remained a significant predictor of line naming even after controlling for all of the nuisance variables (accounting for 9 %). The amount of variance explained here is commensurable with that recently reported by Gale et al (2009) for Snodgrass and Vanderwart (1980) line drawings named in Alzheimer patients. It therefore demonstrates that the influence of category on naming accuracy may occur independently of the effects of other potentially confounding factors and although significant, the effects are relatively small.

As noted above, though no overall category effect emerged, a significant advantage for nonliving things was found when the items were presented as line drawings. Whilst this is consistent with several reports from normative studies of category-specificity (Coppens & Frisinger, 2005; Gaffan & Heywood, 1993; Humphreys, Riddoch, & Quinlan, 1988; Lloyd-Jones & Humphreys, 1997), it has been argued that a failure to control the effects of potentially confounding variables might account for these findings (e.g. Laws & Neve, 1999). Indeed, using more tightly matched sets, researchers have typically reported a normal living advantage (e.g. Brousseau & Buchanan, 2004; Filliter, McMullen & Westwood, 2005; Gerlach, 2001; Laws, 2000; Laws & Neve, 1999; Låg, 2005; Lloyd-Jones & Luckhurst, 2002; McKenna & Parry, 1994). In this context, the findings of this study are of interest as the nonliving advantage occurred despite tightly matching across category for the effects of a large number of nuisance variables, specifically: familiarity, age of acquisition, name agreement, visual complexity, and word frequency. One possible explanation as to why the direction of the category effect reported with the line drawings differs from that of other studies that have employed stringent control over nuisance variables could be that of differences in task demands. Indeed, of those studies that have documented a living advantage, many have employed stimuli on which naming performance is at or near ceiling, thus preventing researchers obtaining normative data. To avoid this, researchers have introduced time constraints to increase task difficulty (e.g. Brousseau & Buchanan, 2004; Låg, 2005; Laws, 2000; Laws & Neve, 1999; Tippett et al., 1996) and in doing so, have reported a living thing advantage. Nevertheless, degrading viewing conditions in this way may create an advantage for items that are structurally similar, specifically, living things (Gerlach, 2001; Laws & Neve, 1999).

In light of the foregoing, it is necessary to treat naming accuracy data with some caution when obtained with stimuli sets on which performance is invariably at ceiling, even when constraints are put in place to prevent performance reaching this level. By contrast, naming latency data may be somewhat more reliable, particularly with sets such as the Snodgrass and Vanderwart (1980) corpus, which, because of the relative ease of naming, would yield little variance in reaction times allowing even small differences in mean latencies to be detected. Despite this, results from reaction time studies are somewhat inconsistent. Though several studies have reported faster reaction times with living things (Brosseau & Buchanan 2004; Laws, Leeson, & Gale 2002a; Lloyd-Jones & Luckhurst, 2002), the opposite profile of performance has also been documented (Humphreys, Riddoch, & Quinlan, 1988), whilst several have failed to find an effect of category altogether (Gale, Laws, & Foley, 2006). Furthermore, of those that have reported category effects, this has typically been documented across subjects, but not items (Brosseau & Buchanan 2004; Lloyd-Jones & Luckhurst, 2002). As such, it is possible that the evidently faster naming of living things is an artifact of the items used. The results of this study failed to provide evidence of a difference in naming latencies across living and nonliving things. Nonetheless, given that naming difficulty varies substantially between the items, reaction time data obtained using the HIT should be treated with caution. For instance, as is evident from the correlation matrix (table 5.5), naming latencies correlate negatively with naming accuracy, which demonstrates a trade-off between the time taken to identify the item and the accuracy of naming. As a result of this, there is likely to be a greater degree of variance in the latency data obtained with this set than would be obtained with sets on which naming accuracy performance is at ceiling, thus making it difficult to detect any fluctuations that might occur across category.

An advantage of the HIT is that the *exact* same items are represented in more than one format, allowing researchers to explore the effects of format on object recognition. Within the context of this study, this meant that we were able to explore whether format interacted with category. Though there was no effect of format for the naming latency data, an interaction between format and category did emerge for naming accuracy. Specifically, participants performed better when items were presented in colour than when they were presented as line drawings. Furthermore, the extent to which format influenced naming differed across category, having a greater effect on the naming of living than nonliving things. As a result, a significant category advantage for nonliving things emerged only when participants were presented with the line-drawn images, which arguably implies that colour is particularly beneficial for the recognition of living things, and therefore, that a lack of surface detail might disadvantage this category. Accordingly, colour was found to be particularly important for the subcategories of birds, insects, fruits, body parts, kitchen utensils, buildings, and foods, the majority of which are from the living domain. This finding is consistent with previous studies that have shown colour to be more beneficial for the naming of living things than for nonliving things, in both healthy controls (Zannino, Perri, Caltagirone & Carlesimo, 2007) and neurologically impaired patients (Humphrey et al., 1994; Montanes, Golblum, & Boller, 1995; Zannino et al., 2007). It is thought that this is because items from the living thing domain are typically more structurally similar (Price & Humphreys, 1989; Wurm et al., 1993), and occur more commonly in a particular colour (Tanaka, Weiskopf, & Williams, 2001) than nonliving things. Nevertheless, that the category advantage for nonliving things, which emerged when items were presented as line drawings, disappeared when they were presented in colour has important implications for studies of category-specificity, given the prevalence with which line-drawn stimuli are used in this area of research.

Chapter 6: Visual Processing in Alzheimer's disease: Surface Detail and Colour fail to aid Object Identification.

6.1 INTRODUCTION

Semantic memory impairment appears to emerge early in the course of Alzheimer's disease (AD), being evident even in Mild Cognitive Impairment cases i.e. pre-AD neuropathology (Joubert, Felician, Barbeau, Didic, Poncet, Ceccaldi, 2008; Vogel, Gade, Stokolm, & Waldemar, 2005). Indeed, estimates concerning the incidence of semantic memory deficits in mild AD suggest it may be as high as 50% (Hodges, Salmon & Butters, 1992). From the earliest reports, the presence of category specific impairments in AD has been contentious. While the prevailing view has been that AD is associated with poorer naming of living things (e.g., animals, fruit, vegetables) relative to man-made items (e.g., clothing, furniture, tools, etc. e.g. Montanes, Goldblum, & Boller, 1995; Laws, Gnoato, Crawford & Sartori, 2007b; Silveri, et al.,1991), others have found no category effects (Hodges et al., 1992; Tippett, Grossman, & Farah, 1996) or impairments of both living and nonliving things (Laws, Gale, Leeson, & Crawford, 2005; Tippett, Meier, Blackwood, & Diaz-Asper, 2007). Indeed, a recent meta-analysis of 21 studies examining category specific naming in over 500 AD patients and 500 controls confirmed that AD patients were significantly impaired at recognising items from both living *and* nonliving domains (Laws, Adlington, Gale, Moreno-Martínez & Sartori, 2007a). And while the majority of individual studies have documented a higher number of living compared with nonliving deficits (13:8 respectively), no significant difference in the effect sizes emerged for living and nonliving naming (d=1.76 and d=1.49 respectively).

The meta-analysis conducted by Laws and co-workers (2007a) also examined the association between colour stimuli and category effects in AD. Of 21 studies analysed, 15 used line drawings and only 6 used colour images. For living things, the difference in effect sizes for line drawings and colour (1.55 vs. 2.64) was significant; for nonliving things, however, it was not (1.45 vs. 1.85). That effect sizes for living and nonliving naming in AD should actually be larger for colour stimuli is unexpected. One possible explanation is that AD patients are less able to process colour information. This may be attributable to early visual impairments reported in some studies of AD patients (Cronin-Golomb, Gilmore, Neargarder, Morrison & Laudate, 2007; Cronin-Golomb, Sugiura, Corkin, & Growdon 1993; Gilmore, Cronin-Golomb, Neargarder, & Morrison, 2005a; Gilmore, Groth, & Thomas, 2005b; Kurylo et al., 1994; Pache et al., 2003; Rizzo, Anderson, Dawson, & Nawrot, 2000; Wijk, Berg, Sivik, & Steen, 1999), associated with the presence of neurofibrillary tangles, which, though low in density in primary visual areas, are seen in increasing numbers in the visual association cortex, particularly in the parietal and temporal lobes (Arnold, Hyman, Flory, Damasio, & Van Hoesen, 1991; Braak, Braak & Kalus, 1989; Lewis, Campbell, Terry & Morrisson, 1987; McKee, Au, Cabral, Kowall, Seshadri, Kubilus, Drake, & Wolf, 2006; Pearson, Esiri, Hiorns, Wilcock, & Powell, 1985). It may therefore be the case that AD patients are unable to process colour information present in the images, and as a result, fail to show the same improvement in performance that is evident in controls.

AD patients do show marked impairments, relative to age matched controls, on tasks that probe colour perception, stereoacuity, contrast sensitivity, backward masking, perceptual organisation, spatial reasoning, and face and object recognition (Cronin-Golomb et al., 2007; Cronin-Golomb et al., 1993; Coyne, Liss, & Geckler, 1984; Miller, 1977; Gilmore et al., 2005a; Gilmore et al., 2005b; Gilmore & Levy, 1991; Nissen, Corkin, Buonanno, Growdon, Wray, & Bauer, 1985; Schlotterer, Moscovitch, & Crapper-McLachlan, 1984; Wijk, Berg, Sivik, & Steen, 1999; Wright, Drasdo, & Harding, 1987). Concerning contrast sensitivity, several studies have shown that AD participants are impaired, relative to age-matched controls, in the recognition of letters, words, and pictures when they are presented at normal or medium contrast (Cronin-Golomb et al., 2007; Gilmore et al., 2005a; Gilmore et al., 2005b). Interestingly, recent findings have shown that increasing stimulus contrast may actually increase AD patients’ performance on tests of letter reading, word reading, face discrimination, and importantly, object recognition, to a level comparable with that of elderly controls (Cronin-Golomb et al., 2007). This suggests therefore, that one source of error on tasks of picture naming may be that AD patients are only able to form weak visual representations of objects when they are presented at normal contrast. It is important to note however, that increasing stimulus contrast only reduced the number of perceptual-type errors made by AD participants, and that although this was found to increase AD performance to a level that was comparable with that of elderly controls, enhancing the stimuli further failed to produce any additional gains.

Though the occurrence of low-level visual impairments in AD might account for the findings of the meta-analysis, this finding contrasts markedly with studies of agnosic patients (e.g., Humphrey, Goodale, Jakobson & Servos, 1994; Mapelli & Behrmann, 1997), which have shown recognition to benefit from colour, especially within the living domain. Given that so few naming studies in AD have departed from using line drawings, for example from the Snodgrass and Vanderwart (1980) corpus or other corpora such as the Boston Naming Test (BNT: Kaplan, Goodglass & Wientraub, 1976), the meta-analytic findings should, perhaps be treated with some caution. One issue with the line drawings typically used in studies is that they are relatively easy for healthy controls to name and even the graded structure of the BNT reveals ceiling effects (for reviews, see Kent & Luszcz, 2002; Hawkins & Bender, 2002). Psychometrically, stimuli derived from the Snodgrass and Vanderwart (1980) corpus and the Boston Naming Test display negative skew (asymmetry) and extreme kurtosis (Hamby, Bardi, & Wilkins, 1997) making it difficult to detect differences at the average to higher average levels of performance.

In the context of category effects, colour is believed to confer specific advantages for the recognition of living things (Markoff, 1972; Price & Humphreys, 1989; Tanaka & Presnell, 1999; Wurm, Legge, Isenberg, & Luebker, 1993) and has been shown to improve naming accuracy for objects judged to have high colour diagnosticity (Oliva & Schyns, 2000; Tanaka & Presnell, 1999) i.e. characterised by a specific colour: for example, carrots are invariably orange. In general, living things tend to have higher colour diagnosticity because their pigment is the product of evolution, rather than whim. Furthermore, some studies have reported that objects are named more readily in greyscale rather than line-drawn format (Brodie, Wallace & Sharrat, 1991; Humphrey et al., 1994) though, importantly, this advantage held only for living things (Humphrey et al., 1994). In short, the addition of surface detail, whether this be coloured or not, appears to play a special role in the recognition of living things, possibly because items in this domain tend to be more structurally similar to each other, and have higher colour diagnosticity (Price & Humphreys, 1989; Tanaka & Presnell, 1999). Kirschner, Webb and Kelly (1984) showed that the naming accuracy of demented patients, but not of healthy controls, varied with the perceptual difficulty of the stimuli they were to name (actual objects vs. drawings vs. drawings masked by background lines). Nonetheless, the patient assessments were conducted before the advent of clear screening criteria for a probable diagnosis of AD and, moreover, the finding that healthy controls were not susceptible to changes in the perceptual nature of objects presented may well be due to ceiling effects associated with easily named stimuli.

It is plausible that line-drawn stimuli (e.g. Snodgrass and Vanderwart, 1980) may specifically disadvantage the recognition of living things, both in healthy controls and patients. As noted, although a few studies have compared naming of colour and non-colour items in AD patients, none used colour and line-drawn versions of exactly the same images. This study investigates the effect of greyscale and colour surface detail on the naming accuracy of AD patients and healthy elderly controls. To avoid the problems associated with ceiling effects in the control group, we selected items from the *Hatfield Image Test* (*HIT*: Adlington, Laws & Gale, 2009), a novel corpus of 147 colour images (available for download from: http://testbed.herts.ac.uk/HIT/hit_apply.asp), which has a graded level of difficulty and, therefore, a more normal distribution of naming accuracy in the normal population. For this study, we used greyscale and line-drawn versions of a subset of 105 items from the *HIT* corpus, matched across living and nonliving domains on relevant naming predictor variables. To explore further the findings of the meta-analysis conducted by Laws et al. (2007a), tests of colour vision and of basic visual functioning were also administered to assess whether AD patients showed deficits in low-level visual functioning relative to controls and any extent to which the latter might influence object naming.

6.2 METHOD

6.2.1 Participants

Forty-one patients with probable Alzheimer’s disease, diagnosed according to NINCDS-ADRDA criteria, were recruited from a memory clinic at the local hospital. Forty elderly healthy controls were also tested. All participants were native English speaking and had normal or corrected-to-normal vision[13]. Patients and controls did not differ significantly in age, education or NART IQ (see Table 6.1). Tests of visual perception were administered to all participants (see below), specifically, the Cortical Visual Screening Test (CORVIST; James, Plant, & Warrington, 2001), and the Ishihara test for colour blindness (Ishihara, 1973).

To avoid potential priming effects across conditions, which might occur if participants saw all three sets of images, we pseudo-randomly assigned participants to one of three conditions, which varied according to the image format used in the naming task. In condition 1, participants were presented with colour versions, in condition 2, greyscale versions and in condition 3, line-drawn versions of the same items. As table 6.1 shows, the patient and control groups were assigned to conditions such that the three patient (or control) groups did not significantly differ from each other in age, education or estimated IQ (obtained using the National Adult Reading Test [NART]: Nelson, 1982). Additionally, the three patient groups did not differ significantly in dementia severity as measured by the Mini Mental State Examination (MMSE: Folstein, Folstein & McHugh, 1975).

[13] The AD patients and controls featured in this study also participated in the investigations reported in Chapters 7 and 8 of this thesis.

Table 6.1 Patient and control demographics

		Colour	Greyscale	Line	*ANOVA*
Age	AD patients	81.6 (5.9)	78.0 (6.8)	78.9 (6.3)	*F=1.2, p=0.3*
	Controls	77.3 (5.9)	76.5 (6.3)	78.1 (4.6)	*F<1*
	ANOVA	*F=3.66; p=.07*	*F<1*	*F<1*	
Education (years)	AD patients	12.3 (3.0)	10.8 (2.6)	10.7 (1.3)	*F=1.8, p=0.2*
	Controls	13.2 (2.3)	12.5 (2.3)	12.4 (3.0)	*F<1*
	ANOVA	*F<1*	*F=3.0; p=.10*	*F=3.58; p=.07*	
Predicted NARTIQ	AD patients	113.4 (5.4)	113.6 (5.9)	111.8 (7.6)	*F<1*
	Controls	116.4 (3.4)	117.0 (3.5)	115.6 (3.3)	*F<1*
	ANOVA	*F=2.94; p=.09*	*F=3.03; p=.10*	*F=2.85; p=.10*	
MMSE score	AD patients	21.3 (6.0)	21.4 (6.0)	23.7 (4.3)	*F<1*

6.2.2 Materials

Hatfield Image Test (HIT: Adlington, Laws & Gale, 2009)

Condition 1 comprised 105 colour images selected from the *Hatfield Image Test* (*HIT*: Adlington, Laws & Gale, 2009); 48 living things (8 animals, 7 flowers, 7 fruits, 7 vegetables, 7 birds, 7 insects and 5 body part items) and 57 nonliving things (5 foods, 7 clothing, 7 furniture, 8 kitchen utensils, 7, tools, 7 vehicles, 7 buildings and 9 musical instrument items). For conditions 2 and 3, greyscale and line-drawn versions of the *HIT* items were used. Figure 6.1 shows examples of images presented in colour, greyscale and line formats.

Figure 6.1 Colour, Greyscale and Line versions of items from the *HIT*

(left –right) Daffodil, pomegranate, praying mantis, artichoke, poncho, sitar, tuk tuk.

Items were matched across living and nonliving domains for name agreement, familiarity, age of acquisition, visual complexity and word frequency (Table 6.2). In all three conditions, images were presented at 283 x 283 pixels on a laptop computer using the Testbed (version 1.0) software, a bespoke experiment-generator program developed at the University of Hertfordshire (Taylor, 2006).

Table 6.2 Matching nuisance variables for living and nonliving items

	Living (n=48)	**Nonliving (n=57)**	**ANOVA**
	***M* (*SD*)**	***M* (*SD*)**	**(df = 1, 104)**
Age of Acquisition [a]	6.7 (1.2)	6.9 (0.9)	1.1 (*p*=0.3)
Familiarity [b]	3.4 (0.5)	3.5 (0.5)	<1 (*p*=0.4)
Name Agreement [c]	47.0 (23.9)	51.2 (21.9)	<1 (*p*=0.4)
Visual Complexity [d]	3.0 (0.4)	3.0 (0.5)	<1 (*p*=0.4)
Word Frequency(log) [e]	15.0 (1.8)	14.8 (1.8)	<1 (*p*=0.6)

[a] Ratings from n=31 (16 male; 15 female); [b] Ratings from n=42 (23 male; 19 female); [c] Name agreement was calculated from the percentage of 152 (69 males; 83 females) healthy participants (mean age 35±20) who correctly named the item; [d] Ratings from n=37 (21 male; 16 female); [e] derived from web hits using the www.altavista.com search engine (following Blair, Urland & Ma, 2002)

The Cortical Visual Screening Test (CORVIST; James, Plant, & Warrington, 2001)

The CORVIST was used to assess the acuity and visual cortical functioning of each patient. Details for each task are provided below:

Symbol Acuity Test: A simplified test of visual acuity that comprises of three shapes (circle, square, and triangle) presented in rows of decreasing size. The test is viewed at normal reading distance. Participants are provided with a viewing window that permits them to see only one item at a time and instructed to work their way across each row, saying aloud the name of each shape. Acuity is recorded in terms of Snellen equivalent.

Shape Discrimination test: The test consists of four oblongs and four squares, matched for flux. Participants are instructed to indicate whether each item is a ‘square’ or ‘oblong’.

Size Discrimination test: Participants are shown four squares and four circles of different size. Initially, they are asked to point to each square in order of size, starting with the largest and this is then repeated for the circles. Poor performance on this may be indicative of bilateral occipital lobe dysfunction.

Shape Detection Test: This test uses complex stimuli to further explore shape discrimination. The task consists of eight seemingly random patterns, four of which contain a circle (‘O’). Participants were asked to say whether an ‘O’ was present/absent from each display. Again, poor performance may be indicative of bilateral occipital impairment.

Hue Discrimination test: This test consists of four arrays of nine coloured blocks, of which all-bar-one are of the same hue, but vary in brightness. The remaining block is of a different hue of medium brightness. For each array, participants are asked to point to the odd one out i.e. the block of a different colour.

Scattered Dot Counting Test: This test assesses difficulties with spatial scanning or localisation of a single point in space. The test consists of four arrays containing different numbers of randomly scattered dots and participants are asked to report the number of dots in each array. Impairment on which may be indicative of damage to the right posterior hemisphere

Fragment Numbers Test: This is designed to assess perceptual identification, impairment of which may be indicative of damage to right parietal areas. The test comprises eight fragmented numbers (numbers 2-9) which the participant is asked to identify.

Word Reading Test: The task consists of two columns of 8 irregularly spelt words, which participants are asked to read each aloud.

Face Perception Test: This test comprises four sets of three faces (two sets of males and two sets of females). Participants are asked to indicate the oldest and youngest face in each set. Poor performance may indicate right parietal lobe dysfunction.

Crowding Test: This test highlights acuity problems for closely spaced items, and may be associated with bilateral occipital lobe dysfunction. The test consists of 4 arrays designed to look like vehicle number plates, the first two of which have letter/number spacing in accordance with UK license plates whilst spacing on the latter two is greater. Participants are asked to read aloud each plate, with the plates being presented at a distance of three metres (with appropriate correction).

6.2.3. Design and Procedure

In all conditions, the 105 images were presented in random order on a laptop computer. Each image remained on-screen until the participant responded. Participants were asked to name each image as quickly and unambiguously as possible by stating only one name, though the name itself could consist of more than one word. So, even if circumlocuting, if the participant eventually gave the correct name, it was counted as correct. In accordance with the normative data obtained for the *HIT* (Adlington, Laws & Gale, 2009), both the dominant name, and the non-dominant names were accepted (e.g. for the item ‘canoe’ the name ‘kayak’ was also accepted). Participants were asked to say ‘don’t know’, if they did not recognise the image.

6.3 RESULTS

Following Clark (1973), we performed all analyses with both participants (F_1) and items (F_2) as random effects in our model. By convention, the F-values obtained with participants as the random factor are referred to by F_1, and items as the random factor as F_2.We also calculated the *minF'* statistic (Clark, 1973), which treats subject and items as random effects in a single ANOVA. As noted in the participants section, the three groups of controls and of AD patients (Table 6.1) tested with each format, did not differ significantly in age, predicted IQ or education (or MMSE score in the case of AD patients).

6.3.1 Do surface texture and colour aid picture naming in AD patients and controls? And, does image format interact with category?

Naming Accuracy of Elderly Controls

As Table 6.3 reveals, image format had a significant impact on naming, with increasing levels of surface detail improving naming accuracy (mean accuracy: line-drawn = 49.94; greyscale = 59.27; colour = 67.62). Similarly, a reliable category effect emerged, with better naming of nonliving (M = 63.59) than living things (M = 50.52). Finally, the interaction between image format and category was also significant. Post hoc analysis revealed a significant difference across category for the line-drawn ($F(1, 104) = 15.83$; $p<0.001$) and greyscale items ($F(1, 104) = 5.85$; $p=0.02$), but disappeared with colour images ($F(1, 104) = 1.59$; $p=0.21$). In other words, although healthy subjects show inferior naming of living than nonliving items, the discrepancy diminishes with the addition of surface detail and colour.

Table 6.3 Control naming performance: format by category

	F_1	F_2	*minF'*
Format	10.9 (2,37) *p*<.01	64.8 (2,103) *p*<.001	9.4 (2,50) *p*<.001
Category	42.6 (1,37) *p*<.01	8.1 (1,103) *p*=.01	6.8 (1,132) *p*=.01
Format by category	4.1 (2,37) *p*=.03	13.4 (2,103) *p*=.001	3.3 (1,61) *p*=.05

Naming Accuracy of Patients

A two-way ANOVA found no main effect of image format, though a significant effect of category and a significant format by category interaction were documented (see Table 6.4). As for controls, patients named more nonliving (*M* = 38.51) than living things (*M* = 25.09). Unlike controls, however, AD patients did not show a significant main effect of format (mean accuracy: line drawings = 30.41; greyscale = 32.86; colour = 33.97), though an interaction between format and category was evident. Post hocs revealed that living things were more poorly named as line drawings (F (1, 104) = 19.4; *p*<0.001), and in greyscale (F (1, 104) = 4.04; *p*=0.05), but no significant difference emerged when presented in colour (F (1, 104) = 3.15; *p*=0.08).

Table 6.4 Patient naming performance: format by category

	F_1	F_2	*minF'*
Format	<1 (2,39) *p*=.59	3.2 (2,103) *p*=.04	<1 (2, 5) *p*=.63
Category	66.9 (1,39) *p*<.01	8.2 (1,103) *p*=.01	7.3 (1,125) *p*=.008
Format by category	4.7 (2,39) *p*=.02	11.4 (2,103) *p*=.001	3.3 (2,73) *p*=.04

In summary it appears that, for AD patients, the effect of format is limited to performance with living things. Moreover, given that there is no difference between the naming of greyscale and colour items, it is possible that it is texture information, rather than colour that is important for the recognition of items from this domain. By contrast, control performance is heavily influenced by image format, both for living and nonliving things, though the effect is more pronounced for living things, in so much as the introduction of colour eliminates the disadvantage for items from this category that is found when images are presented in line-drawn and greyscale formats.

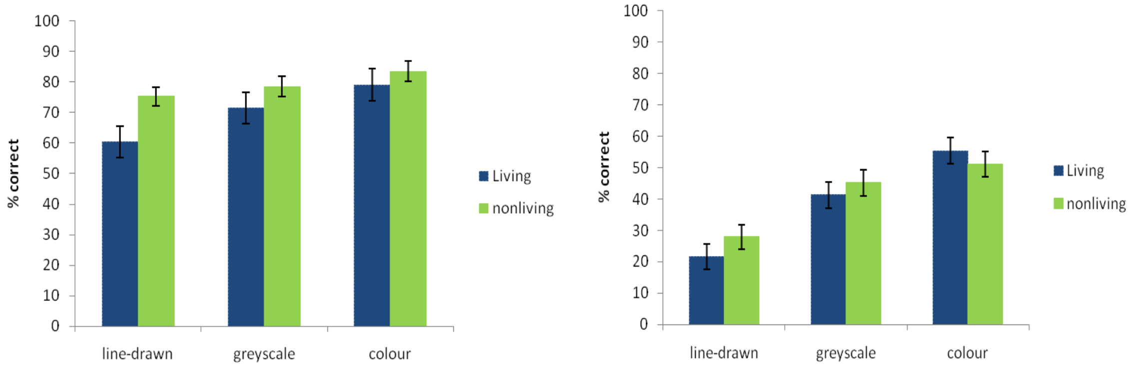
6.3.2 Do category effects in AD reflect Ceiling/Floor effects in control and patient performance respectively?

One important property of the HIT corpus is that, unlike the Snodgrass and Vanderwart corpus, healthy participants perform well below ceiling. Nevertheless, in avoiding ceiling effects, an increase in difficulty may also contribute to the specific pattern of performance observed. We therefore carried out additional analyses to explore whether difficulty influenced the object naming profiles of patients and controls.

The 105 items were divided into two sets according to the criteria outlined in Chapter 5 (see Appendix H for a list of the subsets), with sets matched across category on a number of potentially confounding variables. To ascertain whether difficulty influenced the emergence of a category effect, or the effect of image format on control naming, we carried out separate analyses for the easy and difficult sets. For the easy set, the *minF'* statistic for format (F_1 (2, 37) = 3.55; p=0.04; F_2 (2, 50) = 17.01; p<0.001; *minF'*(2, 52) =2.94, p=0.06) and category (F_1 (1, 37) = 10.88; p=0.002; F_2 (1, 50) = 5.22; p=0.03; *minF'*(1, 84) =3.53, p=0.06) both approached significance. The interaction between format and category was nonsignificant (F_1 (2, 37) = 1.41; p=0.26; F_2 (2, 50) = 2.75; p=0.07; *minF'* (2, 71) <1).

For the difficult set, a significant main effect emerged for format (F_1 (2, 37) = 16.31; p<0.001; F_2 (2, 51) = 50.51; p<0.001; *minF'*(2, 60) =12.33, p<0.001), but not for category (F_1 (1, 37) = 0.76; p=0.39; F_2 (1, 51) = 0.18; p=0.68; *minF'*(1, 72) =0.15, p>0.05), and there was no interaction between format and category (F_1 (2, 37) = 1.96; p=0.16; F_2 (2, 51) = 1.91; p=0.15; *minF'*(2, 86) =0.97, p=0.38). Figure 6.2 shows that controls exhibit a similar pattern of performance as reported in Table 6.3, that the percentage named correctly increases linearly with the addition of surface detail, though this was only found to be significant for the more difficult items.

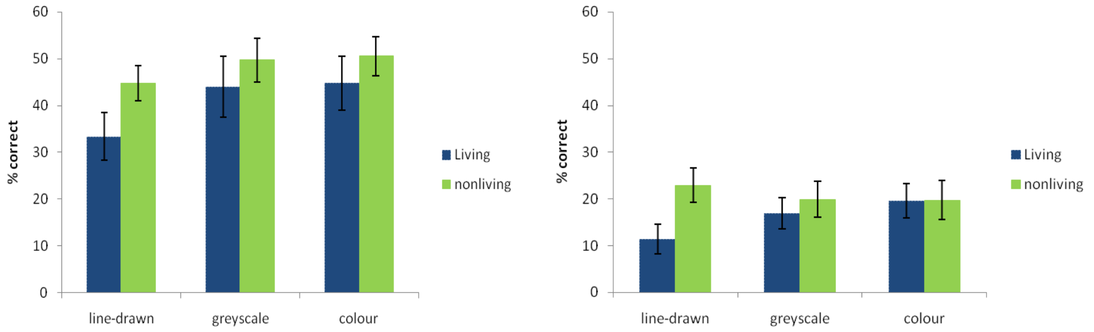
Figure 6.2 Elderly control naming across category on easy (left) and difficult (right) subsets of the HIT



Note. Error bars = standard error

Analyses of the naming performance of patients on the easy set revealed no effect of format (F_1 (2, 39) = 0.61; *p*=0.55; F_2 (2, 50) = 2.79; *p*=0.07; *minF'*(2, 56) =0.5, *p*>0.61), or of category (F_1 (1, 39) = 18.39; *p*<0.001; F_2 (1, 50) = 2.19; *p*=0.14; *minF'*(1, 61) =1.96, *p*>0.05), and no interaction between format and category (F_1 (2, 39) = 3.12; *p*=0.06; F_2 (2, 50) = 3.42; *p*=0.04; *minF'*(2, 86) =1.63, *p*>0.05). Similarly, patients performance on the difficult set showed no main effect of format (F_1 (2, 39) = 0.28; *p*=0.76; F_2 (2, 51) = 0.67; *p*=0.52; *minF'*(2, 69) =0.19, *p*>0.05), or of category (F_1 (1, 39) = 6.86; *p*=0.01; F_2 (1, 51) = 1.17; *p*=0.28; *minF'*(1, 67) =0.99, *p*>0.05), and no interaction between format and category (F_1 (2, 39) = 3.6; *p*=0.04; F_2 (2, 51) = 3.72; *p*=0.03; *minF'*(2, 88) =1.83, *p*>0.05). As is evident from Figure 6.3, this pattern of findings is similar to that obtained for the image set as a whole, in that there is no effect of format on the naming abilities of patients.

Figure 6.3 AD patient naming across category on easy (left) and difficult (right) subsets of the HIT



Note. Error bars = standard error

In summary, these additional analyses demonstrate that although the only significant effect was that of format on control performance, the profile of naming follows the same trend across both image sets. In short, both patients and controls are seen to perform worse with items from the living domain, independent of item difficulty. Nevertheless, regarding the effects of format, it is interesting to note that this is only significant for controls when presented with the difficult subset of items.

6.3.3 Do visual processing problems account for the picture identification problems in AD?

One possible explanation for the discrepancy between format as a predictor of naming accuracy in AD patients and controls is that AD patients are impaired in their ability to perceive colour information as a result of damage to the visual cortex. To explore this idea, we compared patients and controls on the Ishihara colour blindness test and the CORVIST (Cortical Visual Screening Test: James et al., 2001, see Table 6.5). On the Ishihara test, no significant differences emerged in the number of patients and controls who were found to be colour blind[14], or to exhibit red-green deficiencies. Conversely, performance was found to differ significantly between patients and controls on all parts of the CORVIST with the exception of the size discrimination task. On all tasks, controls outperformed patients, showing that the AD patients displayed some basic visual-perceptual difficulties.

Table 6.5 Comparison of AD patients and elderly controls on the Ishihara and Cortical Visual Screening Test battery

Tests		Z-score
Ishihara	Colour blindness test	-0.7
CORVIST	Visual acuity	-4.2^{a}
	Shape Discrimination	-2.4^{b}
	Size Discrimination	-1.5
	Shape Detection	-3.4^{a}
	Hue Discrimination	-5.2^{a}
	Dots	-2.0^{b}
	Fragments	-5.4^{a}
	Words	-4.0^{a}
	Faces	-4.8^{a}
	Crowding	-3.3^{a}

Note. Mann Whitney ^{a} p<0.001; ^{b} p<0.05

The extent to which such basic visual-perceptual deficits might account for naming performance was explored further. We used regression analyses to determine whether performance on the CORVIST predicts the naming of all items, as well as items from the living and nonliving domains separately. To this end, the tests from the CORVIST were divided into two sets - those tapping low-level *visual*

[14] Using the Ishihara, two AD patients and 2 controls were found to be colour-blind. In addition, one AD patient exhibited red-green deficiencies.

processes (lowZ; visual acuity, shape discrimination, size discrimination, shape detection, and hue discrimination), and those demanding higher-level *perceptual* processes (highZ; dot counting, fragments, words, face recognition, visual crowding). For each group, the Z-score was calculated. MMSE score correlates significantly with highZ (r=.40; p<.01), but not lowZ (r=.22; p>.05). This supports the notion that those tasks grouped to provide the highZ score, are those that involve higher order cognitive processes.

The factors lowZ and highZ were entered into the regression analyses as predictors, alongside age, education, NART score, and image format, all of which have been previously shown to affect object recognition. Tolerance was at an acceptable level for all predictors in the regression analyses conducted for AD patients (lowest 0.53) and controls (lowest 0.78).

Table 6.6 Regression analysis examining predictors for picture naming in healthy controls and AD patients

Controls	Total Correct *r*=.38		Living things Correct *r*=.40		Nonliving things Correct *r*=.21	
	S-P	*t*	*S-P*	*t*	*S-P*	*t*
Sex	-.06	-0.3	-.17	-0.9	.08	0.5
Age	-.09	-0.5	-.02	-0.1	-.13	-0.8
Education	-.31	-1.9	-.22	-1.3	-.34	-2.1[c]
Image format	.63	4.6[a]	.65	4.8[a]	.50	3.2[b]
NART	.29	1.7	.29	1.7	.22	1.3
lowZ	.24	1.4	.25	1.5	.18	1.0
highZ	-.03	-0.2	-.05	-0.3	-.01	-0.1

AD patients	Total Correct *r*=.31		Living things Correct *r*=.30		Nonliving things Correct *r*=.35	
	S-P	*t*	*S-P*	*t*	*S-P*	*t*
Sex	.11	0.6	-.20	-0.7	.38	2.3[c]
Age	-.42	-2.6[b]	-.33	-1.2	-.43	-2.8[b]
Education	-.04	-0.2	-.06	-0.3	-.02	-0.1
Image format	.35	2.2	.48	3.1[b]	.13	0.8
NART	.32	1.9	.35	2.2[c]	.22	1.3
lowZ	.42	2.7[b]	.44	2.8[b]	.32	2.0
highZ	-.19	-1.1	-.24	-1.4	-.10	-0.6
MMSE	.36	2.2[c]	.25	1.5	.38	2.4[c]

Note. S-P = semi-partial correlations; [a] $p<0.001$; [b] $p<0.01$; [c] $p<0.05$

Table 6.6 shows the regression results for controls and AD patients. For controls, image format significantly influences naming performance with an increase in surface detail correlating positively with naming for living things ($r=0.62$; $p<0.01$), nonliving things ($r=0.47$; $p<0.01$), and overall naming

(r=0.60; p<0.01). Similarly, the number of years in education was predictive of naming ability for nonliving things. As might be expected, number of years in education was found to correlate positively with NART score both for patients (r=0.35; p<0.05) and for controls (r=0.34; p<0.05). By contrast, the naming performance of AD patients appears to depend on several factors, the most predominant of which is the occurrence of low-level visual impairments, which correlated positively with the naming of living things (r=0.35; p<0.05), nonliving things (r=0.34; p<0.05), and naming overall (r=0.39; p<0.05). For naming overall, and for nonliving things, age, MMSE score, and sex all emerged as predictors, whilst for living things; image format was also found to significantly predict naming, and again, to positively correlate with naming (r=0.31; p<0.05) indicating therefore that performance with living things increased with the amount of surface detail present in the image. An additional hierarchical regression entering all of the variables in Table 6.6 with lowZ entered last, revealed that even after controlling for all other variables (which combined accounted for 30% of variance) lowZ significantly accounted for a further 10% (ΔR^2) of variance in total naming.

In short, compared to elderly controls, AD patients were significantly impaired on tasks of visual functioning and this impairment along with image format and NART score predicts the ability of AD patients to name living things. By contrast, the factors predicting naming of nonliving things in AD patients were the demographic variables of age, sex, and MMSE score. For controls, the main factor predicting naming across both living and nonliving things was image format, with education also emerging as a predictor for nonliving things.

6.4 DISCUSSION

As far as the author is aware, this study of AD patients and controls is the first to compare naming for exactly the same images across line-drawn, greyscale and full-colour format. The main aims of this study were: (i) to explore the effect of image format on object naming in AD patients and controls; (ii) to establish whether the recognition of living things is differentially linked to image format and, in particular, the presence of colour; and (iii) to see whether patients exhibit low-level visual deficits relative to controls, that might account for object naming performance. To explore these issues, we compared the ability of AD patients and elderly healthy controls to name either 105 high quality colour, greyscale, or line-drawn images derived from the *Hatfield Image Test* (Adlington, Laws & Gale, 2009). Furthermore, we examined the role of item difficulty by dividing the corpus into a difficult and an easy set.

As with the majority of previous studies (for a review, see Laws et al., 2007), AD patients named fewer living than nonliving things despite careful stimulus matching across category (cf. Tippett, Meier, Blackwood & Diaz-Asper, 2007; Moreno-Martínez & Laws 2007). It is notable that elderly controls showed the same advantage for naming nonliving things and so, although quantitatively worse, AD patients show a qualitatively similar naming profile (see Gale, Irvine, Laws, & Ferrissey, 2009; Moreno-Martinez & Laws, 2007; 2008). Moreover, though the naming of living things was only significantly worse than that of nonliving things when performance was analysed across the corpus as a whole, the same pattern of performance was apparent in the easy and difficult sets for both AD patients and controls and so is unlikely to be an artefact of using low frequency or low familiarity items.

For both AD patients and elderly controls, a significant category-by-format interaction emerged. By contrast, an effect for image format emerged only in controls, with the AD patients showing no naming benefit from the addition of either surface detail or colour over line drawings. Concerning the performance of elderly controls, the effect of format is consistent with previous research (Humphrey et al., 1994; Price & Humphreys, 1989; Wurm, Legge, Isenberg, & Luebker, 1993) in that naming accuracy improved additively i.e. controls named significantly more items when presented as colour images, than when viewing the greyscale and line-drawn images. Moreover, image format significantly predicted naming both for living and for nonliving things. Nevertheless, it is apparent that the use of line drawings produced the largest advantage for the naming of nonliving over living things (both for patients and healthy controls); and indeed, for both patients and elderly controls, the significant category advantage for nonliving things disappeared with the coloured versions. When the same analyses were conducted for the easy and difficult subsets, the effect of format previously noted for elderly controls emerged only for the difficult items i.e. those items less easy to name from shape alone (as indicated by line). The finding is in keeping with studies generally reporting colour to be advantageous when shape alone is less useful for disambiguating the target from competing representations (Laws & Hunter, 2006; Price & Humphreys, 1989; Tanaka & Presnell, 1999). Interestingly, this applied equally to living and nonliving items and thus, provides no support for the notion of greater structural overlap for living items (cf. Price & Humphreys, 1989).

By contrast, AD patients failed to benefit from the provision of additional visual information in the form of surface texture or colour. Indeed, the regression analyses revealed that while image format predicted naming of living things, the addition of colour appears to produce little or no benefit for naming nonliving things, with mean performances being indistinguishable across the three image formats. This may be related partly to the presence of low-level visual impairment in the AD patients. Indeed, lowZ accounted significantly for a further 10% of naming variance even after controlling for *all* other variables (i.e. age, sex, education, NART IQ, dementia severity (MMSE), image format, and highZ). This strongly suggests that, regardless of current or pre-morbid cognitive ability, AD patients are unable to process some of the low-level visual information necessary for object recognition. For example, the finding that hue discrimination was impaired is consistent with our findings for the failure to benefit from colour information. Indeed, the lack of a colour effect in Alzheimer patients accords with the presence of colour vision impairments associated with this disorder (see Cronin-Golomb, Sugiura, Corkin, & Growdon 1993; Kurylo et al., 1994; Pache et al., 2003; Rizzo, Anderson, Dawson, & Nawrot, 2000; Wijk, Berg, Sivik, & Steen, 1999). The occurrence of senile plaques, neurofibrillary tangles and astrocytic gliosis in the striate cortex (Beach & McGeer 1988) is consistent with the visual dysfunction in AD patients reflecting neuropathology of the visual cortex rather than the retina or optic nerve (Holroyd & Shepherd, 2001). We found no significant relationship between MMSE scores and low-level visual performance on the CORVIST, although MMSE did correlate with high-level visual performance. Previous work also shows that deficits in colour discrimination and stereoacuity do not correlate with dementia severity, implying that such deficits are not secondary consequences of attentional or motivational impairments (Cronin-Golomb et al., 1991).

Given the effect of format on control naming, and the interaction between format and category, it is unsurprising that regression analyses revealed format to be the largest predictor of naming performance for both living and nonliving things. The number of years in education also emerged as a predictor of nonliving naming in elderly controls, and may therefore be tapping into the broad range of familiarity for the HIT items (cf. Snodgrass and Vanderwart items). By contrast, analysis of the predictors of AD patients naming revealed that several factors influenced performance, and moreover, that these differed between living and nonliving things. The naming of living things was predicted by the occurrence of low-level visual impairments, image format, and NART score, while naming of nonliving things was dependent upon sex, age and MMSE score. Hence, it seems that the naming of nonliving things varies more as a function of patient characteristics, while naming of living things is largely dependent upon visual factors, specifically variability in the richness of visual stimuli compounded by the difficulties that AD patients have in processing quite low-level visual information.

The finding that the ability of AD patients to name living things is more dependent upon visual factors accords with the ideas of Warrington and co-workers (Warrington & McCarthy, 1987; Warrington & Shallice, 1984), who suggested that the recognition of living things is largely reliant upon sensory information. As such, the presence of low-level visual impairments in AD might be more detrimental to the naming of living things than nonliving things. Indeed, if, as the findings from this study suggest, surface details are more important for the recognition of living things, then impairment of basic visual processes responsible for processing this information would consequently impair the recognition of living things to a greater extent than nonliving things. It is possible therefore, that this might account for the high incidence of living thing deficits reported in the AD literature (Laws et al., 2007). By contrast, our analyses revealed that naming of nonliving things in AD patients was largely dependent upon demographic factors such as age, sex and MMSE score, such that those patients who were more likely to exhibit better naming of nonliving things, were younger males, with higher MMSE scores.

To summarise, the findings indicate that different variables influence the naming of living and nonliving things in AD patients and healthy elderly controls. Specifically, surface information such as texture and colour may be more beneficial to the naming of living than nonliving things for both patients and controls, but that owing to the low-level visual impairments experienced by persons with AD, their ability to process such information is impaired. This in turn, may account for the deficit for living things typically reported by studies of AD patients. By contrast, the naming of nonliving things by AD patients is heavily dependent upon the demographic factors of age, sex, and disease severity as indicated by MMSE score. The latter mixture of variables could then sometimes lead to nonliving deficits in some patients (e.g. in older female patients with lower MMSE scores). That different factors predict naming of living and nonliving things is consistent with these domains reflecting quite different underlying processes.

Chapter 7: A longitudinal Investigation of Category-specificity in Alzheimer's Dementia

7.1 INTRODUCTION

Alzheimer's dementia (AD) is a progressive neurodegenerative disorder which accounts for approximately half (50-60%) of all cases of dementia (Cummings & Benson, 1992). Given this high prevalence, AD is one of the most extensively studied conditions in the context of semantic memory impairment. It is well known that AD patients show impaired performance on semantic tasks (Bayles & Tomoeda, 1983; Bayles, Tomoeda, & Trosset, 1990; Chertkow & Bub, 1990; Done & Gale, 1997; Hodges, Salmon, & Butters, 1991; Martin & Fedio, 1983; Salmon, Butters, & Chan, 1999), and that this is an early feature of AD, evident in approximately half of all mild AD cases (Hodges, Salmon & Butters, 1992), and even observed in cases of Mild Cognitive Impairment (i.e. pre-AD; Joubert, Felician, Barbeau, Didic, Poncet, Ceccaldi, 2008; Vogel, Gade, Stokolm, & Waldemar, 2005).

Several researchers have argued that poor performance on tests of semantic memory may be attributed to problems with access and/or retrieval of conceptual information, rather than degradation of the semantic store (Bayles, Tomoeda, Kaszniak, & Trosset, 1991; Nebes & Brady, 1990; Nebes, Boller, &Holland, 1986; Nebes, Martin, & Horn, 1984; Nebes, 1989; Ober, Shenaut, & Reed, 1995). However, the majority of studies provide evidence for a disorder of semantic storage, in accordance with the criteria outlined by Warrington and Shallice (Shallice, 1988a, 1988b; Warrington & Shallice, 1984). Thus, studies have reported: (i) consistency in performance across semantic tests within a given modality (Chertkow & Bub, 1990; Hodges, Salmon, & Butters, 1992; Rogers, Patterson, Ivanoiu, & Hodges, 2006); (ii) preservation of superordinate knowledge with loss of subordinate knowledge (Chertkow & Bub, 1990; Hodges, Salmon, & Butters, 1992): (iii) loss of semantic priming effects (Hernández, Costa, Juncadella, Sebastián-Gallés, & Reñé, 2008), and (iv) greater loss of low frequency items (Hodges, Salmon, & Butters, 1992).

Though the majority of researchers agree that semantic memory impairment is characteristic of AD; whether this impairment is category specific remains contentious, with studies producing a somewhat inconsistent profile of findings (for review, see Laws, Adlington, Gale, Moreno-Martinez, and Sartori, 2007). As discussed in chapter 1, the emergence of category specific impairments in AD has important implications for theoretical models of semantic memory, since many of these relate functional modularity to localised substrate damage. However findings from AD patients raise challenges for some of these models, since these patients exhibit significant semantic impairment under more widely distributed neuropathology. In an attempt to account for the emergence of category specific deficits in AD, several researchers have proposed that deficits for living and nonliving things may be traced back to a single underlying variable that reflects the degree of cognitive impairment (as measured by naming ability or dementia severity). Connectionist accounts of semantic memory propose that differences in the number of intercorrelated features, and the distinctiveness of features representing living and nonliving things might account for category specific dissociations. For example, Gonnerman and co-workers (Gonnerman, Andersen, Devlin, Kempler & Seidenberg, 1997) introduced two factors; *distinguishing features*, which permit discrimination between members of a category, and *intercorrelations* between semantic features within an objects' representation. The former is described as being a feature that occurs almost exclusively for a particular item (e.g. HAS TINES - A FORK), and, importantly, tends to relate to the functional properties of nonliving things and the perceptual properties of living things. Intercorrelated features refer to pairs of features that are activated simultaneously for many words in the lexicon, thus, 'HAS- FINS' and 'HAS-A-TAIL' would be intercorrelated as they are often jointly activated. Crucially, Gonnerman and co-workers (Gonnerman et al., 1997; Devlin et al., 1998) argue that living things have more intercorrelated features, whilst nonliving things have more distinguishing features. In this way, small amounts of neural damage would be unlikely to impair naming of living things because the high level of connectivity between features can compensate for the removal of some connections, though as the disease progresses and damage accumulates, the collateral support provided by the remaining intercorrelations would be insufficient to compensate for loss, leading to living thing impairment. By contrast, relatively small amounts of random damage could isolate distinctive features, making nonliving things vulnerable to damage very early on. Nevertheless, as there are very few interconnections, damage to specific distinguishing features would not affect the entire category in the same way, meaning that later in the disease, living things would actually be more impaired than nonliving things.

A similar account to that proposed by Gonnerman et al. has been put forward by Durrant-Peatfield and colleagues (Durrant-Peatfield, Tyler, Moss, & Levy, 1997). This however differs in that they place greater emphasis on the correlation between form and function. Functional information is seen as salient to both living and nonliving things, though there are differences in the type of functional information important to each category, and the distinctiveness and correlatedness of the perceptual information to which functional information is inextricably linked. For living things, there are numerous correlations between shared biological functions and shared perceptual features that support these functions (e.g. HAS EYES-CAN SEE), though the number of distinctive properties is fewer and the form-function relationship is typically weak making these vulnerable to damage. By contrast, nonliving things tend to have strong correlations between distinctive form-function properties, as form is highly diagnostic of function, though the number of shared properties is less than that for living things. In light of this, Durrant-Peatfield and colleagues argued that living things would be more vulnerable to low levels of impairment, as this would result in loss of weakly correlated distinctive properties making it difficult to distinguish between living things. Greater levels of damage would however have a more noticeable impact on nonliving things, as the loss of numerous distinctive correlations would result in a reliance on shared connections which are fewer in number than is the case for living things.

Though the connectionist models may be useful in that they provide detailed accounts of how category specific deficits might emerge in AD, they are nevertheless, mutually exclusive in that they propose that the level of impairment has opposing effects on category naming. In addition, evidence in support of these models is somewhat lacking. Indeed, much of the evidence cited in favour of the model proposed by Durrant-Peatfield and colleagues (Durrant-Peatfield, Tyler, Moss, & Levy, 1997) is computational in nature (i.e. Durrant-Peatfield, Tyler, Moss, & Levy, 1997; Tyler, Moss, Durrant-Peatfield, & Levy, 2000). Table 7.1 displays findings from longitudinal and cross-sectional studies of category effects in AD. From this, it is apparent that only one study provides any support for the connectionist accounts discussed above. Gonnerman et al., (1997) obtained some support for their model. In a longitudinal study of 15 AD patients, 13/15 exhibited a crossover from a nonliving impairment to a living impairment. By contrast, the largest and perhaps most comprehensive longitudinal analysis of naming in AD patients failed to find any support for the notion that a cross over coincides with disease progression (Garrard et al., 1998). Rather, their study shows that whether participants exhibit a deficit for living or nonliving things, this deficit increases as the disease progresses.

Though there is a general lack of support for these connectionist accounts, one issue that is highlighted by this, and by the studies conducted subsequently to explore category-specificity in relation to level of impairment, is the heterogeneity of performance within the AD population. From table 7.1, it is apparent that the direction of the category effect is varied. Moreover, Gonnerman et al., (1997), and also Garrard et al., (1998), did not find an effect of category at the group level, though at the individual level, participants exhibited both living and nonliving thing deficits. This suggests therefore that, given the degree of heterogeneity found in category naming, the net effect may be to mask category effects in group analyses.

Table 7.1 Summary of cross-sectional and longitudinal studies of category specific naming in AD

Study	Methodology	MMSE Mean/range	Controls (Y/N)	Controls at ceiling (Y/N)	Category effect found?	Direction	Profile
Cuetos et al., 2008[i]	Long– 2 patients	P1=20-11 P2=15-10	N	-	No	-	-
Duarte et al., 2009	CS	Min AD = 24.76 Mild AD = 21.2 Mod AD = 15.27	Y	Y (L=99.19-100%; NL = 99.35-100%)	No	-	Trend towards L deficit in mild AD group on the naming task
Garrard et al., 1998	CS	19.9	Y	Y (L=93%; NL=97%)	No[a] Yes[b]	- L and NL	- Category effect size increased with increasing anomia
Garrard et al., 2001[ii]	Long & CS	Long =19.9 CS=23.6	N	-	No	-	-
Gonnerman et al., 1997[iii]	Long & CS	Long; GP =18-12; NB = 21-11 CS = 19.0	N	-	No[a] Yes[b]	- L and NL	- Changes from NL to L deficit with disease progression
Moreno-Martinez et al., 2008[iv]	Long	21.2	Y	N (L=86.7%; NL = 95.2%)[c]	Yes (3/14 patients)	L and NL	Only 3AD cases exhibited dissociation: 2=LT deficit, 1=NLT deficit. In later analysis, only 1 NLT

Study	Methodology	MMSE Mean/range	Controls (Y/N)	Controls at ceiling (Y/N)	Category effect found?	Direction	Profile
							deficit emerged.
Tippett et al., 2007	CS	18.6/10-28	Y	Expt 1 – Y (L=97.4%; NL = 95.9%) Expt 2 – Y (L=95.6%; NL = 95.1%) Expt 3 – N (L=90.2%; NL = 90.1%)	Yes & No[d]	L and NL[e]	NL deficit with mild anomia, LT deficit with greater anomia
Whatmough et al., 2003	CS	23.0	Y	N (L=82.6%; NL=82.5%)	Yes	L	Category effect size increased with increasing anomia
Zannino et al., 2002	CS	20.6	Y	Y (L=93.3%; NL=94.3%)	Yes	L	Category effect size increased with increasing anomia

Notes:long = longitudinal study, CS = cross sectional study, [a] at group level, [b] at individual level [c] though approaching ceiling, [d] depending on which variables controlled for, [e]when elderly controls not performing at ceiling. [i] both patients completed 2 test stages, for patient 1, there was a three year interval, and for patient 2, a two year interval between stages; [ii] report data from four testing sessions over three years; [iii] patient GP was tested eight times over four years, NB was tested four times over two years, both at 6-monthly intervals; [iv] report data from two testing sessions with one year interval.

In addition to the issue of heterogeneity, it may also be argued that the discrepancy among findings may be attributed to methodological factors, namely, the problem of ceiling effects in control performance, and inadequate control of nuisance variables. A study by Tippett, Meier, Blackwood, and Diaz-Asper (2007) addresses both these issues. These authors assessed the extent to which control of potentially confounding factors such as familiarity, age of acquisition, name agreement, and elderly control naming accuracy might influence the emergence of category specific effects. Their findings revealed that whether a category effect emerged, and also the direction of the resultant category effect, depended upon which variables were controlled, the closeness of matching, and whether control data was below ceiling. Moreover, hierarchical regression analyses showed that while name agreement and age of acquisition were found to predict naming both in AD patients and elderly controls, category did not emerge as a significant predictor. Though Tippett and colleagues are certainly not the first to demonstrate that nuisance variables might influence category specific naming, (e.g. Funnell & Sheridan, 1992; Stewart, Parkin & Hunkin, 1992) it is interesting to note that closeness of matching might also play a role, and thus highlights the need for caution in studies of this nature. Indeed, as table 7.2 shows, there is much variability in longitudinal and cross-sectional studies of category-specificity, as to which variables are controlled.

Table 7.2 Variables controlled (+) in longitudinal and cross-sectional studies of AD patients

Study	**Intrinsic variables controlled**										
	AoA	Fam	Freq	IA	Img	LF	LW	NA	NAc	Pro	VC
Cuetos et al. (2008)	+	+			+	+	+				+
Duarte et al., (2009)	+	+	+				+				
Garrard et al. (1998)						+				+	
Garrard et al. (2001)	+	+				+				+	
Gonnerman et al. (1997) Exp 1 & 2			+							+	
Moreno-Martínez et al. (2008)	+	+	+			+		+		+	+
Tippett et al. (2007) Exp 1		+				+					+
Tippett et al. (2007) Exp 2	+					+		+	+		
Tippett et al. (2007) Exp 3		+							+		
Whatmough et al. (2003)		+							+		
Zannino et al. (2002)	+	+		+[i]		+		+		+[i]	+[i]

Note: AoA = age of acquisition, Fam = familiarity, Freq = wall street Journal Frequency counts, IA = image agreement, Img = imageability, LF = lexical frequency, LW = length of word, NA = name agreement, NAc = name accuracy, NF = Name frequency, VC = visual complexity. [i] according to English speaking norms.

Tippett and colleagues also demonstrate that the use of control subjects who are performing below ceiling can influence the way in which we interpret patient data. This is perhaps more evident in the work of Laws et al., (2005), who illustrated how failure to use controls, or the use of controls performing at ceiling could distort both the degree and type of category deficit reported, resulting in false positive, false negative, and paradoxical dissociations. In spite of this, though control data is used in 5/8 of the longitudinal and cross-sectional analyses that explore category-specificity in AD, only one study (Whatmough et al., 2003) other than that of Tippett et al uses controls performing below ceiling. It may be argued that, since it is possible to make within-group comparisons over time, and therefore observe changes in the patient naming profile, the use of controls is less important. Nevertheless, it is necessary to compare patients to controls, so that the correct profile of dissociation is obtained at each time point. Moreover, controls should also be tested longitudinally rather than using the same data set at each time point, to allow for fluctuations in performance that might occur.

Indeed, if for example, patient performance with nonliving things remained consistent over time but controls performance improved due to practice effects, patients would actually show a deficit for nonliving things at the later time points when referenced to controls. Importantly, if controls were at ceiling in the first instance, this would also mask any practice effects that might occur over time.

Several of the longitudinal and cross-sectional studies referenced above rely solely on the use of one semantic task, typically picture naming (Cuetos et al., 2008; Moreno-Martínez et al., 2008; Tippett et al., 2007; Whatmough et al., 2003, though for use of a semantic battery see Garrard, Lambon Ralph, Watson, Powis, Patterson, & Hodges, 2001; Garrard, Patterson, Watson, & Hodges, 1998; Gonnerman et al., 1997; Zannino et al., 2002). Given the high item-by-item consistency across tasks tapping semantic memory (Chertkow & Bub, 1990; Hodges, Salmon, & Butters, 1992; Rogers, Patterson, Ivanoiu, & Hodges, 2006), this is arguably an acceptable approach. However, the use of a semantic battery would allow researchers the opportunity to explore semantic memory across the semantic hierarchy; from superordinate to subordinate levels, across different modalities, and to pinpoint the level at which a particular deficit emerges (i.e. at access, comprehension, or retrieval). Moreover, as noted by Garrard et al (1998), this may highlight dissociated cases that are not apparent based on naming performance alone.

The aims of this study were therefore to conduct a longitudinal investigation of category specific semantic processing in AD, in reference to healthy controls, using a battery of semantic tasks. A longitudinal design, rather than cross-sectional approach was chosen to avoid some of the problems of cohort effects associated with the use of the latter, and also to allow greater exploration of change over time, so that any changes observed may be attributed to disease proggression. In accordance with Moreno-Martínez and colleagues (Moreno-Martínez, Laws, Goñi-Imízcoz, & Sánchez Martínez, 2008), participants were tested over a minimum of a one year period, though were also tested again after 16-months on the picture naming task as this proved the most informative measure of performance. AD patients were compared to healthy controls, using stimuli on which normal performance is below ceiling, and which are tightly matched across category on several factors known to influence performance, namely, the Hatfield Image Test (HIT: Adlington, Laws, & Gale, 2009). An advantage to using the HIT is that colour, greyscale and line-drawn versions of each item are available. As such, it was decided that this study would also determine whether the presence of surface information (i.e. colour and/or texture) influenced object recognition. With regard to AD patients, very few studies have been carried out to assess the extent to which colour may influence object recognition. Moreover, of those studies that do, findings are mixed, with some suggesting that colour is only important for the recognition of living things (Montanes, Goldblum, & Boller, 1995; Zannino, Perri, Caltagirone, & Carlesimo, 2007), whilst more recent work suggests that colour does not benefit object recognition in AD at all (Adlington, Laws, & Gale, in press). Thus, it was hoped that a more comprehensive analysis of the influence of surface detail on AD performance would provide further insight into object recognition in AD.

7.2 METHOD

7.2.1 Participants

Data were initially obtained from (i) 42 patients (22 female, 20 male) with probable Alzheimer's disease, diagnosed at the memory disorders clinic at the QEII hospital according to NINCDS-ADRDA criteria, and (ii) 40 controls (20 female, 20 male) the majority of whom were taken from the community, though approximately a quarter were the spouses of patients participating in the study. All agreed to participate in a longitudinal study of semantic memory over a 16 month period, in which they would be tested at three, six-monthly intervals (0 months, 6 months, and 12 months), and then again at 16 months. All were native English speaking and had normal or corrected-to-normal vision. Participants were randomly allocated to one of three conditions, in which they were shown either the colour, greyscale, or line-drawn versions of the HIT (see table 7.3). Information about age, educational level, predicted IQ (as measured by the National adult reading test – NART: Nelson, 1982) and the MMSE scores (Mini Mental State Examination: Folstein, Folstein, & McHugh, 1975) of these groups are provided in table 7.4.

Table 7.3 Mean (standard deviation) background details for controls and AD patients within each format group

	Colour	Greyscale	Line
AD patients	n=15 (8f, 7m)	n=13 (7f, 6m)	n=14 (7f,7m)
Controls	n= 13 (6f, 7m)	n=13 (7f, 6m)	n=14 (7f, 7m)

Table 7.4 Mean (standard deviation) background details for controls and AD patients

		Colour	**Greyscale**	**Line**	**ANOVA**
Age	AD patients	81.6 (5.9)	78.0 (6.8)	78.93 (6.33)	F=1.2, *p*=0.3
	Controls	77.31 (5.9)	76.54 (6.3)	78.14 (4.6)	F<1
	ANOVA	*F=3.9; p=0.06*	*F<1*	*F<1*	
Education (years)	AD patients	12.3 (3.0)	10.8 (2.6)	10.7 (1.33)	F=1.8, *p*=0.17
	Controls	13.2 (2.3)	12.5 (2.3)	12.4 (3.0)	F<1
	ANOVA	*F=3.17; p=0.09*	*F=1.22; p=0.28*	*F=1.45; p=0.24*	
Predicted IQ (NART)	AD patients	113.4 (5.4)	113.6 (5.9)	111.8 (7.6)	F<1
	Controls	116.4 (3.4)	117.0(3.5)	115.6 (3.3)	F<1
	ANOVA	*F = 1.29; p=0.27*	*F<1*	*F=2.27; p=0.14*	
MMSE score	AD patients	21.3 (6.0)	21.4 (6.0)	23.7 (4.3)	F<1
	Controls	29.4 (0.7)	29.4 (0.8)	28.7 (2.5)	F<1
	ANOVA	*F=21.3; p<0.001*	*F= 16.8; p<0.001*	*F=18.2; p<0.001*	

7.2.2 Materials

The stimuli used in this study were derived from a set of 105 items (48 living things and 57 non-living things) with normative data for familiarity, age of acquisition, visual complexity, word frequency, name agreement, and colour diagnosticity. Participants were exposed to all items only for the naming task. For the picture-sorting task, eight out of a possible fifteen subcategories were used (animals, flowers, fruits, vegetables, vehicles, furniture, tools, and kitchen utensils), with six items chosen to represent each subcategory. For the word-picture matching task, participants saw five items from each of the fifteen subcategories. The items used in the word-picture matching task were included in the picture-sorting task.

Items were presented to participants in colour, greyscale, or black and white. The format to which the participants were exposed remained the same for all experimental tasks. The medium used to present the images varied between the tasks. For the naming and word-picture matching tasks, a laptop computer and Testbed (version 1.0) software was used to present the images. In the former, images were 283x283 pixels. In the latter, images were scaled to 220x220 pixels to allow five images to be presented on screen simultaneously. For the picture-sorting task, the images were transferred onto 10x10cm flash cards. In all instances, the images were presented on a white background, and at the same orientation.

7.2.3 Procedure

At each testing session, participants completed picture naming, picture-sorting, and word-picture matching tasks. In addition to these tasks, which are described in detail below in the order in which they were administered, participants were also asked to complete the National Adult Reading Test (NART; Nelson, 1978) during the initial testing session, and the Mini Mental State Examination (MMSE; Folstein, Folstein & McHugh, 1975) in all testing sessions. Demographic information relating to age, educational background, and anti-dementia medication, was also obtained in the first session.

Naming task: For the purpose of this task, 105 images were presented in random succession using a laptop computer and the Testbed (Version 1.0) software package. Each image was preceded by a cross (+) for 500ms, and a brief blank screen (150ms), and was presented on screen until the participant responded. In this time, participants were asked to name each image as briefly and unambiguously as possible, by saying aloud only one name, though the name itself could consist of more than one word. Participants were asked to say 'don't know', if the image was unknown to them, or to say 'tip of the tongue' if they were momentarily unable to remember the name. Their responses were recorded by the experimenter.

Picture Sorting Task: In this task, images were presented as flash cards, 10cm x 10cm in size. Items representing the living thing categories of animals, flowers, fruits, and vegetables, and the non-living thing categories of vehicles, furniture, tools and kitchen utensils were included. Six stimulus items were chosen to represent each subcategory; therefore, there were 24 living, and 24 nonliving items in total.

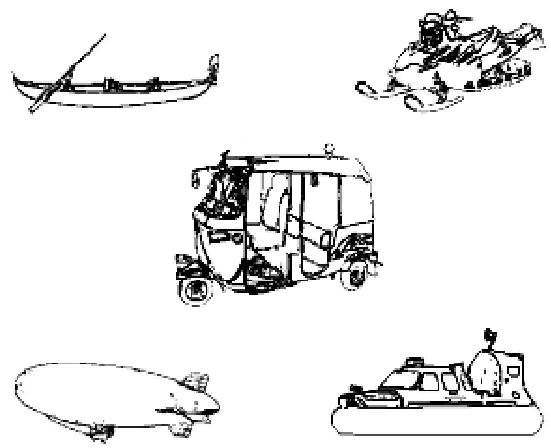
Participants were asked to sort items (i) on the basis of category membership, and (ii) on the basis of attributes. The subcategories and attributes used in this task are featured in table 7.5. As can be seen from this, participants were first asked to distinguish between subcategories that were very dissimilar in terms of the visual and functional attributes of the members (i.e. flowers and animals), and then between subcategories that were similar in their attributes (i.e. tools and kitchen utensils). Concerning the attribute questions, these were further subdivided to include *visual* and *functional* attributes. In each instance, participants were provided with two headings relating either to the subcategory (e.g. FLOWERS and ANIMALS), or the attributes of the items (e.g. LARGER THAN A PEACH and SMALLER THAN A PEACH). The relevant cards were then shuffled and handed to the participant as a pile. Participants were instructed to place the cards under the appropriate heading, and were told that they could come back to those items that they were least certain about after sorting those that felt certain they were correct in placing.

Table 7.5 The headings used by participants to sort items in the picture-sorting task

		HEADINGS	
Subcategory Membership	*Dissimilar subcategories*	Animals Vehicles	Flowers Furniture
	Similar Subcategories	Fruits Tools	Vegetables Kitchen Utensils
Attributes Possessed by the Items		***Animals***	
	Visual	Larger than a German Shepherd dog	Smaller than a German Shepherd dog
	Functional	Carnivore	Herbivore
		Fruits	
	Visual	Larger than a Peach	Smaller than a peach
	Functional	Native to Britain	Not native to Britain
		Vehicles	
	Visual	Larger than a Land Rover car	Smaller than a Land Rover car
	Functional	Used to travel on land	Not used to travel on land
		Furniture	
	Visual	Larger than a dining room chair	Smaller than a dining room chair
	Functional	Is used for seating	Is not used for seating

Word-Picture Matching Task: For this task, images were once again presented using a laptop computer and the Testbed (version 1.0) software. As in the naming task, each stimulus presentation was preceded by a cross (+) for 500ms, and a brief blank screen (150ms). Each stimulus presentation consisted of five items, all representing the same subcategory (e.g. five birds, five buildings etc.). Items were arranged on screen as shown in figure 7.1. At each stimulus presentation; participants were given the name of an item that appeared on screen, and asked to point to the item that matched that name. This process was then repeated for the four remaining unnamed items. The order in which participants were asked to match word to picture was randomised, both in regard to the order in which the subcategories were presented, and the order in which the names of the items on screen were given. All responses were recorded by the experimenter.

Figure7.1 Screenshots of the word-picture matching stimuli presented in colour, greyscale, and line-drawn format (not at full size).

		
(left-right); blue bell, crocus, honeysuckle, daffodil, and hyacinth	(left-right): fly, silverfish, praying mantis, daddy long legs, and bee	(left-right): gondola, snow mobile, tuk tuk, airship, and hovercraft

7. 3. RESULTS

7.3.1 NAMING DATA ACROSS TIME: IS THERE AN EFFECT OF CATEGORY AND FORMAT?

Control Data

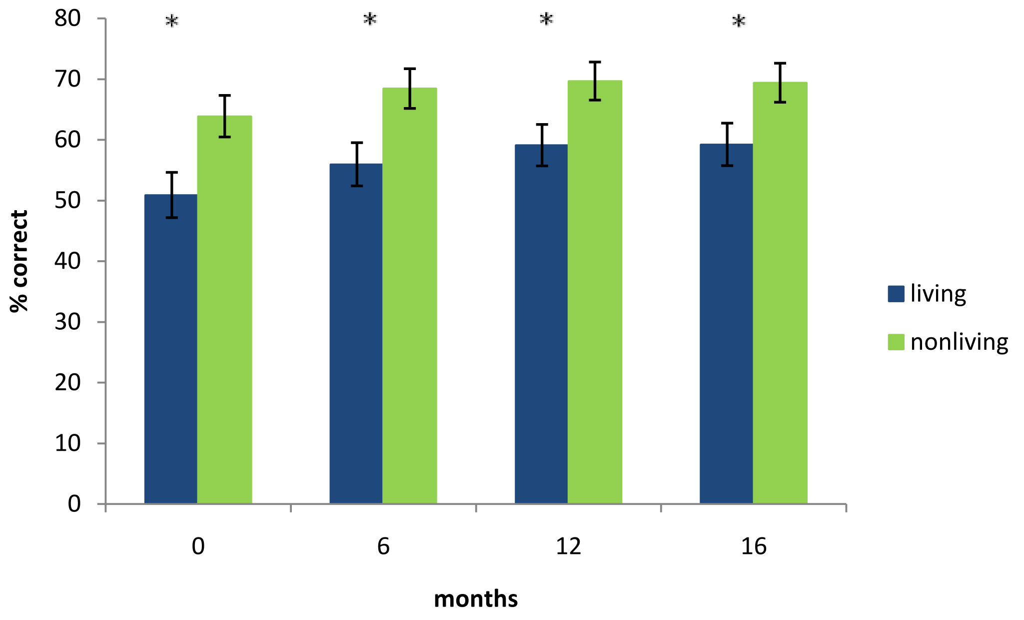
A three-way ANOVA was used to analyse controls naming performance, with time entered as a repeated measure. Analysis of the control data yielded a significant effect of time and category, but no main effect of format (see table 7.6). Similarly, there were no significant interactions. The overall mean performance at each time point was at 0 months = 57.39%, at 6 months = 62.19%, at 12 months = 64.38%, and at 16 months 64.31%. Controls performed significantly better with nonliving things across all testing sessions[15].

Table 7.6 ANOVA results for control naming performance: time x category x format

	F_1	F_2	*minF'*
Time	37.66; (3, 33) *p*<.001	25.57; (3, 103) *p*<.001	**15.23; (3, 119) *p*<.001**
Category	33.36;(1, 33) *p*<.001	7.68; (1, 103) *p*=.01	**6.24; (1, 134) *p*=.01**
Format	1.65; (2, 33) *p*=.21	63.52; (2, 103)*p*<.001	1.61; (2, 35) *p*=.22
Time x category	F<1; (3, 33)	1.15; (3, 103) *p*=.33	F<1; (3, 74)
Time x format	F<1; (6, 33)	38.37; (6, 103) *p*=.01	F<1; (6, 94)
Format x category	2.21; (2, 33) *p*=.13	7.48; (2, 103)*p*=.001	1.71; (2, 54) *p*=.19
Time x category x format	1.25; (6, 36) *p*=.30	3.32; (6, 103) *p*=.01	F<1; (6, 60)

[15] The overall performance of controls was found to improve significantly across the first three sessions (0-6 months: t=-5.90, p<0.001; 6-12 months: t=-3.42, p<0.001). This increase was not significant between the third and fourth sessions (12-16 months: t=0.81; p>0.05).

Figure 7.2 Longitudinal control naming profile across category



Note: error bars denote standard error; * denote category differences significant at $p<0.001$

Patient Data

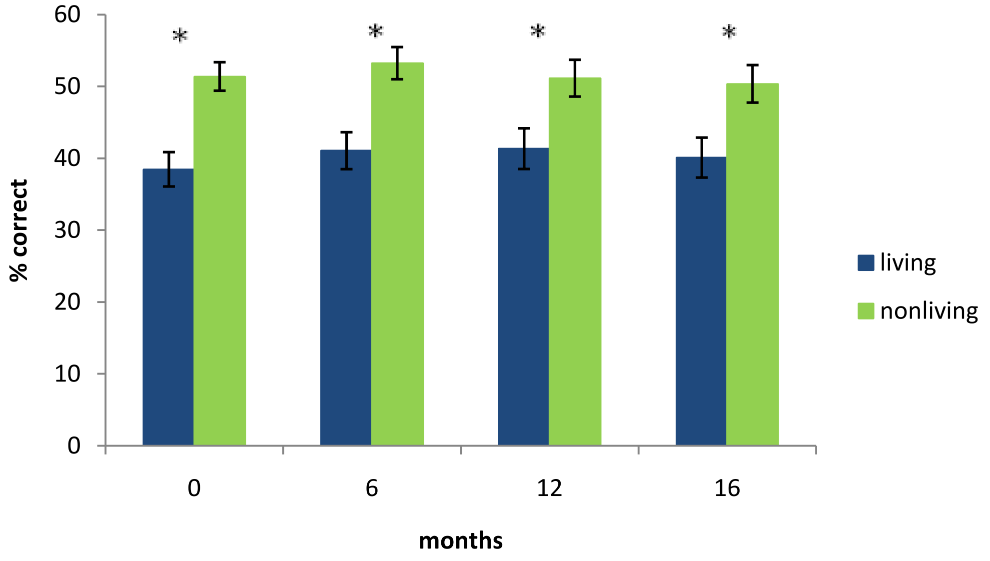
As with the control group, table 7.7 shows that analysis of AD patient performance revealed a significant effect of time and category, but no main effect of format. The mean overall scores at each time point were at 0 months = 31.85%, at 6 months = 32.74%, at 12 months = 28.66%, and at 16 months = 28.86%. Of the interactions, none were significant based on the minF*'*, though time by category was significant when analysed by subjects, and by items. Post hoc analyses revealed a significant effect of category at each time point, with patients consistently performing significantly better with nonliving things (see figure 7.3)[16].

[16] Analyses revealed that patient performance decreased significantly at each time point, after the 6 month testing session (6-12 months: t=4.96, p<0.001; 12-16 months: t= 4.22, p<0.001). Between 0 and 6 months performance appeared to improve, with mean performance increasing from 32.5% correct, to 33.05% correct, though this did not reach significance (0-6 months: t=-0.68; p>0.05). As all participants were recruited to the study within three months of being prescribed anti-dementia medication, this increase may be attributed to the effects of medication on cognition.

Table 7.7 ANOVA results for AD patient naming performance: time x category x format

	F_1	F_2	*minF'*
Time	19.49; (3, 35) *p*<.001	15.34; (3, 103) *p*<.001	**8.58; (3, 117) *p*<.001**
Category	32.01;(1, 35) *p*<.001	5.53; (1, 103) *p*=.02	**4.72; (1, 133) *p*=.03**
Format	2.02; (2, 35) *p*=.15	11.26; (2, 103)*p*<.001	1.71; (2, 48) *p*=.19
Time x category	4.09; (3, 35) *p*=.01	3.67 (3, 103) ; *p*=.01	1.93; (3, 110) *p*=.13
Time x format	F<1; (6, 35)	1.12; (6, 103) *p*=.35	F<1; (6, 94)
Format x category	F<1; (2, 35)	13.22; (2, 103)*p*<.001	F<1; (2, 40)
Time x category x format	2.75; (6, 35) *p*=.02	F<1; (6, 103)	F<1; (6, 135)

Figure 7.3 Longitudinal patient naming profile across category



Note: error bars denote standard error; * denote category differences significant at *p*<0.001

Previous studies have shown that the category effect documented in AD patients may be influenced by control performance. Thus, the patient data was transformed into z-scores based on the means and standard deviations of the naming performance of controls. AD patient performance was then reanalysed in a series of one-way ANOVAs comparing z-scores across category for each time point and format. Based on this, a significant category effect only emerged when patients were presented with the line-drawn items, at the 6 month (F_1 (1, 13) = 10.45; p=0.007; F_2 (1, 104) = 12.64; p<0.001; *minF'* (1, 40) = 5.72; p<0.05), 12 month (F_1 (1, 12) = 10.76; p=0.007; F_2 (1, 104) =18.55; p<0.001; *minF'* (1, 29) = 6.81; p<0.01), and 16 month (F_1 (1, 12) = 10.73; p=0.007; F_2 (1, 104) = 17.98; p<0.001; *minF'* (1, 29) = 6.72; p<0.05) testing sessions.

Discussion

In summary, analysis of control data revealed a significant effect of category and of time, with consistently fewer living things named correctly. Performance across time was seen to improve significantly between all time points except 12 and 16 months at which point performance appeared to plateau. When analysed alone, AD patient data revealed the same significant effect of category, performing worse with living things at all time points. A significant main effect of time also emerged, however in this instance, performance significantly deteriorated across all time points except between 0 and 6 months when performance was seen to improve (though not significantly). Given that the first test session was carried out around the time that participants began treatment with anti-dementia medication, it is possible that this improvement in performance may occur as a result of treatment.

Patient data was reanalysed using z-scores based on the means and standard deviations of controls. In contrast to the analysis of patient data alone, an effect of category was only observed when items were presented as line drawings, and only at the 6, 12, and 16 month testing sessions. This suggests therefore, the pattern of performance exhibited by patients differs quantitatively, but not qualitatively from that of controls.

7.3.2 WORD-PICTURE MATCHING ACROSS TIME, CATEGORY AND FORMAT

Data pertaining to control and AD patient performance on the word-picture matching task was collected at 0, 6, and 12 months only. This data was analysed in the same way as the naming data, using ANOVA to explore naming across time, category, and format.

Control data analyses

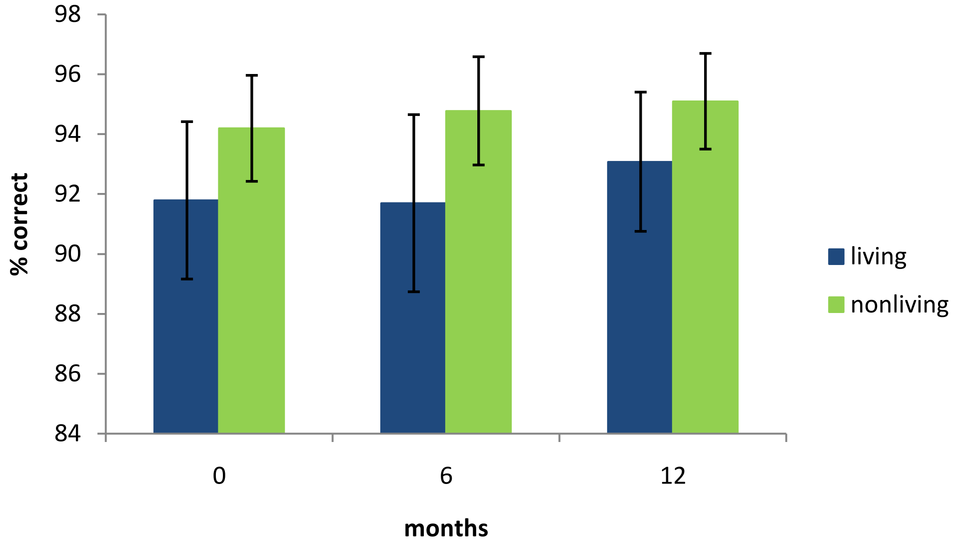
Analysis of control performance on the word-picture matching task failed to reveal any main effects or interactions. Thus, there was no effect of time, category, or format. Moreover, there was no interaction between time and category, format and category, or time and format, and no overall interaction between time, category and format.

Table 7.8 ANOVA results for control performance on the word-picture matching task: time x category x format

	F_1	F_2	*minF'*
Time	1.91; (2, 33) *p*=.16	10.87; (2, 73) *p*<.001	1.62; (2, 45) *p*=.21
Category	7.02;(1, 33) *p*<.01	1.95; (1, 73) *p*=.17	1.53; (1, 102) *p*=.22
Format	F<1; (2, 33)	1.19; (2, 73)*p*=.31	F<1; (2, 62)
Time x category	F<1; (2, 33)	F<1; (2, 73)	F<1; (2, 80)
Time x format	F<1; (4, 33)	1.53; (4, 73) *p*=.19	F<1; (4, 50)
Format x category	F<1; (2, 33	F<1; (2, 73)	F<1; (2, 106)
Time x category x format	F<1; (4, 33)	1.28; (4, 73)	F<1; (4, 72)

Figure 7.4 shows that there is little variance in control word-picture matching performance across time and category. Nevertheless, in this instance this may be because performance is at ceiling level. Indeed, controls perform at above 90% accuracy across living and nonliving things, across all time points.

Figure 7.4 Control performance on the word-picture matching task across time and across category



Note: error bars denote standard error

AD patient analyses

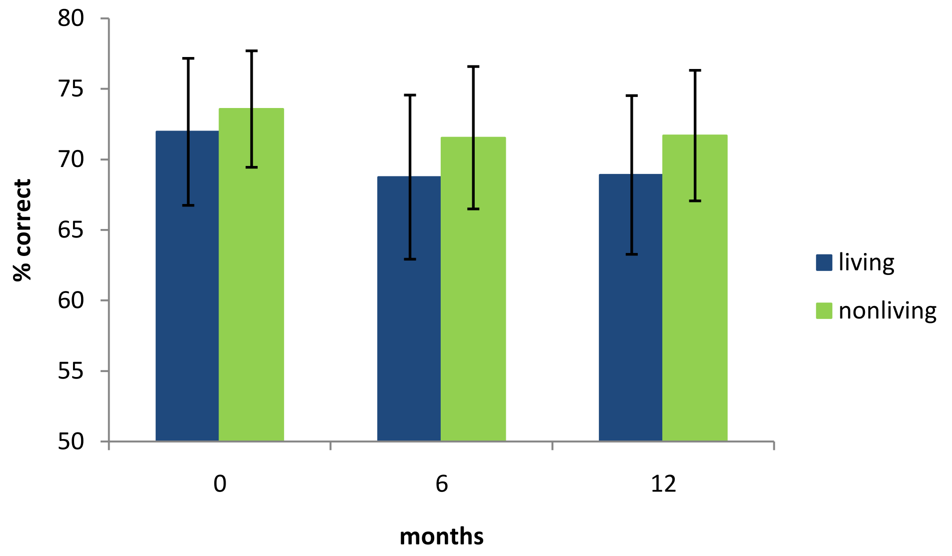
Analysis of AD patients' performance on the word-picture matching task found no main effect of time, category, or format. Similarly, there was no interaction between time and category, format and category, or format and time. There was also no overall interaction between time, category, and format (see table 7.9).

Table 7.9 ANOVA results for AD patient performance on the word-picture matching task: time x category x format

	F_1	F_2	*minF'*
Time	1.62; (2, 35) *p*=.21	1.72; (2, 73) *p*=.18	F<1; (2, 93)
Category	1.62;(1, 35) *p*=.21	F<1; (1, 73)	F<1; (1, 92)
Format	F<1; (2, 35)	F<1; (2, 73)	F<1; (2, 40)
Time x category	F<1; (2, 35)	F<1; (2, 73)	F<1; (2, 60)
Time x format	F<1; (4, 35)	1.46; (4, 73)	F<1; (4, 57)
Format x category	F<1; (2, 35)	F<1; (2, 73)	F<1; (2, 108)
Time x category x format	F<1; (4, 35)	1.32; (4, 73)	F<1; (4, 72)

Figure 7.5 reveals little variance in AD performance with living and nonliving things on the word-picture-matching task, though performance appears to be worse with living things. This is consistent across time, with there being little difference in overall performance with time. Reanalysis of this data using control performance to calculate z-scores was consistent with previous findings failing to document an effect of category at any time point.

Figure 7.5 AD patient performance over time and category on the word-picture matching task



Note: error bars denote standard error

Discussion

In summary, analyses of the control and patient data failed to reveal any significant main effects or significant interactions. Across time, performance of controls and patients remained consistent. Across category, both controls and patients performed worse with living things though this did not reach significance. There was also no effect of category in AD patient scores when analyses were carried out in which control performance was used to calculate z-scores for patient performance.

7.3.3 PICTURE SORTING TASK

Given the nature of this task, in that the same items were not used at all levels, analyses were only conducted by subjects (F_1). For both patients and controls, performance was initially analysed at the subcategory level, to explore their ability to differentiate between items from very different subcategories within the same category (e.g. animals v flowers), and their ability to differentiate between similar subcategories within the same category (e.g. fruits v vegetables).

Performance at the subordinate level was then explored; participants were asked to differentiate between items within a subcategory based on a particular feature (e.g., whether an item of furniture could be used as seating). The features, about which questions were posed, were either visual or functional in nature.

For all analyses, the percentage of items correctly sorted is based on the number of items that were placed under the correct heading. Therefore, if a ‘fruit’ item was placed under the heading ‘vegetables’, this was recorded as incorrect only for fruits, not for vegetables. In this way, the scores for each subcategory reflect accuracy only for those items belonging to that subcategory.

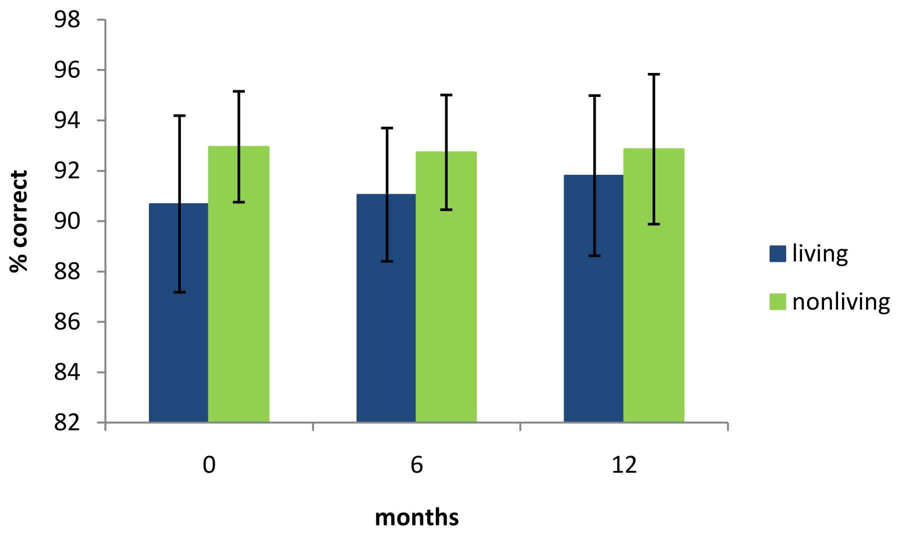
Control performance on the picture-sorting tasks; similar versus dissimilar subcategory decisions.

Table 7.10 shows the findings of a three-way ANOVA to explore control naming across time, format, and category when participants were asked to sort items from similar living/nonliving subcategories. Performance was analysed in the same way for the dissimilar subcategories though this group were found to score 100% at all time points and across all formats, therefore it was not possible to analyse this data. Turning to performance on the similar subcategories, table 7.10 shows that there were no significant differences in performance. This may again be attributed to ceiling level performance on this task, as figure 7.6 illustrates.

Table 7.10 ANOVA results for control performance across living and nonliving things on the similar subcategory sorting task: time x category x format

	Similar
Time	F<1; (2, 33)
Category	1.68;(1, 33) *p*=.20
Format	2.23; (2, 33) *p*=.12
Time x category	F<1; (2, 33)
Time x format	F<1; (4, 33)
Format x category	F<1; (2, 33)
Time x category x format	1.25; (4, 33) *p*=.30

Figure 7.6 Comparison of control performance across time and category on the similar picture sorting by subcategory tasks.



Note: error bars denote standard error

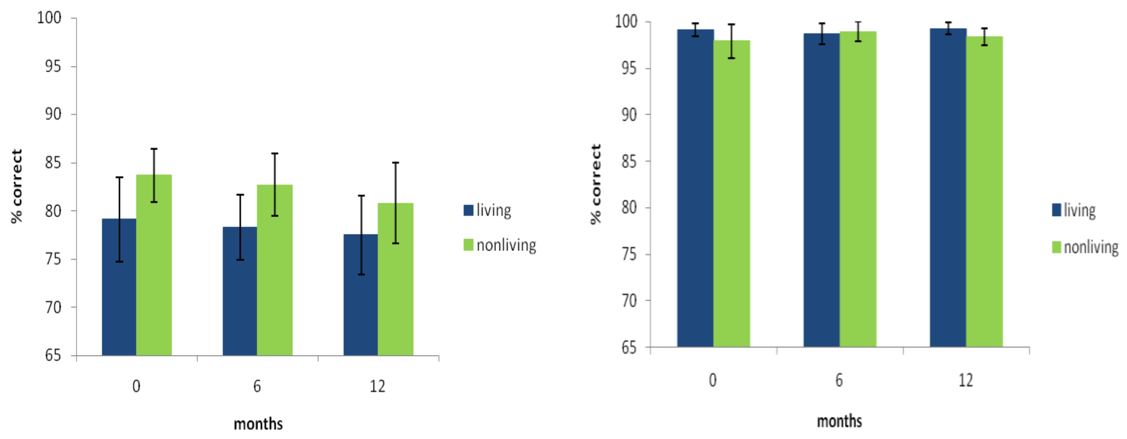
Patient Performance on the picture-sorting tasks; similar versus dissimilar subcategory decisions.

Patient data was initially analysed in the same way as that of controls. As table 7.11 shows, analyses revealed that the only significant effect was that of category when items were from similar subcategories. Concerning this, figure 7.7 indicates patients were found to be better at sorting items from similar nonliving subcategories, than from similar living subcategories. This was however, only significant at the 6 month testing session (t=-2.19; $p<0.05$). Moreover, this advantage for nonliving things was not evident in performance on the dissimilar sorting task. However, this may have been masked by the fact that patients performed at ceiling.

Table 7.11 ANOVA results for AD patient performance across living and nonliving things on the similar and dissimilar subcategory sorting task: time x category x format

	F-values	
	Similar	Dissimilar
Time	F<1; (2, 35)	F<1; (2, 35)
Category	**7.46;(1, 35) *p*<.01**	1.88; (1, 35) *p*=.18
Format	F<1; (2, 35)	1.20; (2, 35) *p*=.31
Time x category	F<1; (2, 35)	1.11; (2, 35) *p*=.34
Time x format	F<1; (4, 35)	1.67; (4, 35) *p*=.17
Format x category	F<1; (2, 35)	1.28; (2,35) *p*=.29
Time x category x format	F<1; (4, 35)	F<1; (4, 35)

Figure 7.7 Comparison of patient performance across time and category on the similar (left) and dissimilar (right) picture sorting by subcategory tasks



Note: error bars denote standard error

As the effect of category was found to differ dependent upon whether participants were sorting items from similar or dissimilar categories, further analyses were conducted to explore whether the level of similarity interacted with category. For the purpose of this analysis, scores were collapsed across time and format to produce a mean score[17]. Thus, a two-way ANOVA was carried out to explore the interaction between similarity and category. This revealed a significant main effect of similarity (F (1,37) = 279.09; p<0.001), and of category (F (1,37) = 3.98; p=0.05). In addition, there was a significant interaction between similarity and category (F (1,37) =10.56; p<0.01). From figure 7.7, it is apparent that for the dissimilar items, there is little difference in sorting across category. Indeed, whilst performance is slightly better with living than nonliving things, this did not reach significance (t=1.55; p=0.002). By contrast, for the similar items, there was a significant difference in performance across category, with patients showing a significant disadvantage for living things (t=-2.69; p=0.01).

As for the picture naming and word-picture matching tasks, the means and standard deviations of controls were used to calculate patient z-scores. However, in this instance, given that controls scored

[17] Analyses were conducted to explore the influence of time and format on performance. These showed that there was no significant main effect of either variable, and neither was found to interact with similarity or category, therefore these variables were removed from all subsequent analyses.

100% across all time points and all formats on the dissimilar task, it was only possible to calculate z-scores for patient performance on the similar task. In doing so, this revealed that a significant deficit for living things was only found at the 12 month testing session, and only when items were presented as line drawings ($F(1, 12) = 4.60$; $p=0.05$).

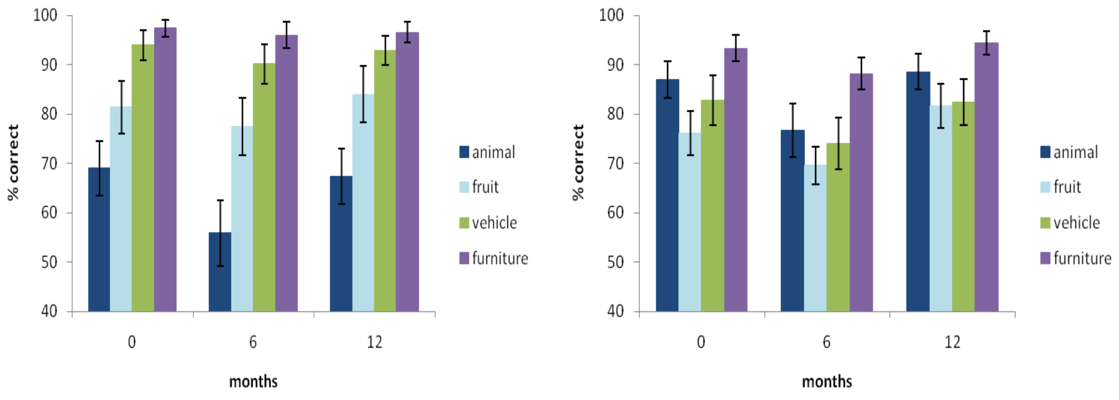
Control Performance on the picture-sorting tasks; visual and functional subordinate level processing

In addition to sorting between subcategories, participants were also required to sort items at the subordinate level, within each subcategory, on the basis of visual or functional features of the items. As table 7.12 shows, analyses revealed a significant main effect of subcategory and time across both tasks, and an interaction between time, subcategory, and format in the functional task. Figures 7.8 and 7.9 show that on the functional task, performance is worst with the living subcategories, and best with the nonliving subcategories, across all time points and formats. By comparison, in the visual task, participants perform better with animals and furniture, than with vehicles and fruit.

Table 7.12 ANOVA results for control performance on the visual and functional within subcategory sorting tasks: time x category x format

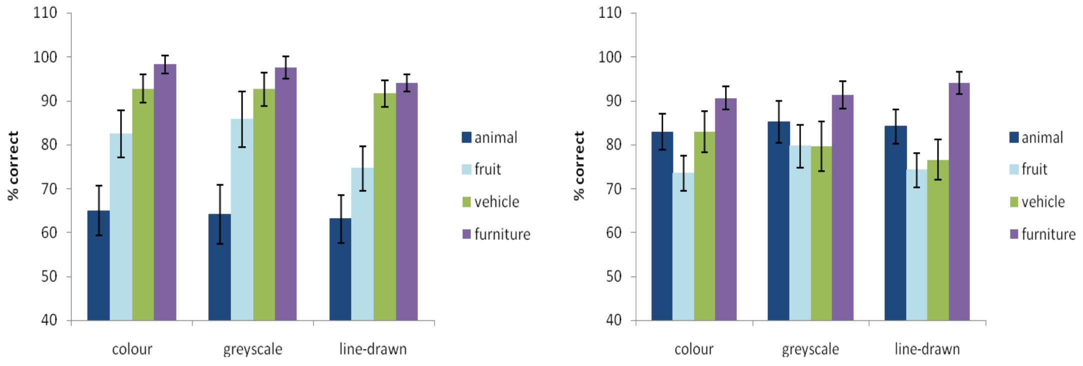
	F-values	
	Functional	Visual
Time	**6.41; (2, 33) *p*<.01**	**17.17; (2, 33) *p*<.001**
Subcategory	**71.20; (1, 33) *p*<.001**	**19.12;(1, 33) *p*<.001**
Format	1.46; (2, 33) *p*=.25	F<1; (2, 33)
Time x subcategory	1.84; (2, 33) *p*=.09	F<1; (2, 33)
Time x format	F<1; (4, 33)	F<1; (4, 33)
Format x subcategory	F<1; (2,33)	1.03; (2, 33) *p*=.41
Time x subcategory x format	**1.88; (4, 33) *p*<.05**	1.40; (4, 33) *p*=.17

Figure 7.8 Comparison of control performance across time and category on the functional (left) and visual (right) picture sorting within subcategory tasks



Note: error bars denote standard error

Figure 7.9 Influence of format on control performance across subcategory on the functional (left) and visual (right) picture sorting within subcategory tasks



Note: error bars denote standard error

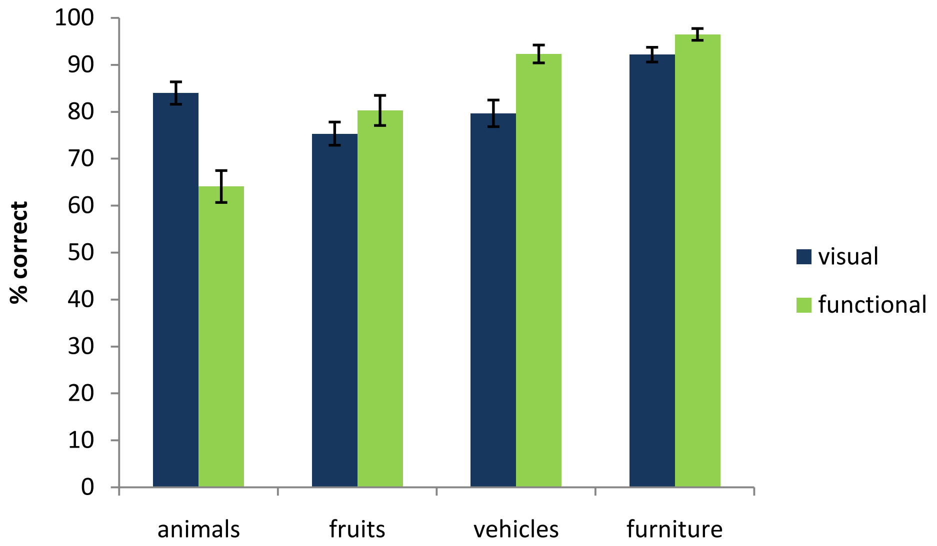
Further analyses were conducted to explore whether attribute (i.e. visual or functional) interacted with control performance across subcategory and across time. Though format was found to interact with time and subcategory, in the functional analysis presented in table 7.12, further exploration revealed that performance on each subcategory, at each time point, was not found to differ significantly across format. Therefore, in all subsequent analyses scores were collapsed across format. A three-way ANOVA was thus conducted to explore the interaction between time, subcategory, and attribute, the results of which are presented in table 7.13. This again revealed a significant main effect of time and subcategory, but also revealed an interaction between time and subcategory, and between attribute and subcategory. Concerning the interaction between time and subcategory, post hocs revealed only one significant difference in subcategory performance across time, with a significant increase noted in performance with fruits between the first and third testing sessions ($t=-2.31$; $p<0.05$).

Table 7.13 ANOVA for results control performance; the interaction between time, attribute, and subcategory.

	F-values
Time	**19.02; (2, 35) *p*<.001**
Subcategory	**55.58; (3, 35) *p*<.001**
Attribute	F<1; (1, 35)
Time x subcategory	**2.86; (6, 35) *p*=.01**
Time x attribute	1.76; (2, 35) p=.18
attribute x subcategory	**43.08; (3, 35) *p*<.001**
Time x subcategory x attribute	F<1; (6, 37)

Regarding the interaction between attribute and subcategory, from figure 7.10 it is apparent that while controls perform better on the visual task in relation to animals, on all other subcategories, performance is better on the functional task. Post hoc analyses revealed that for all time points, controls performed better on the visual task in relation to animals (0 months: t=-4.27; p<0.001; 6 months: t=-4.57; p<0.001; 12 months: t=-5.9; p<0.001). For vehicles, the opposite is true, with controls performing better on the functional task at all time points (0 months: t=3.01; p<0.001; 6 months: t=5.86; p<0.001; 12 months: t=3.59; p<0.001). For fruits and furniture, performance across attribute task differed only at the second time point, with controls performing better on the functional task in relation to both the fruits (t=2.31; p=0.03), and furniture (t=2.93; p=0.01) subcategories.

Figure 7.10 Control performance across subcategory on the visual and functional tasks (collapsed across time and format)



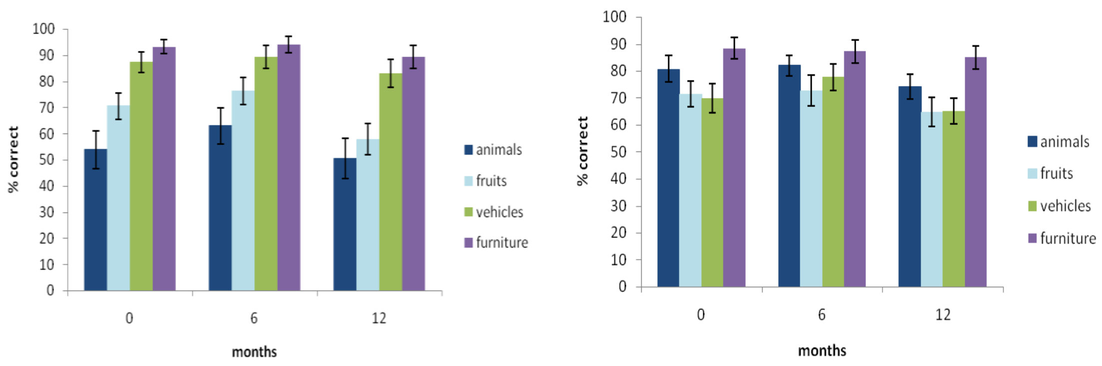
Patient performance on the picture sorting task; visual and functional subordinate level processing.

Concerning patient performance on the within subcategory, or subordinate level tasks, the findings are presented in table 7.14. This reveals significant main effects of both time and subcategory on both tasks.

Table 7.14 ANOVA results for patient performance on the visual and functional within subcategory sorting task: time x category x format

	F-values	
	Visual	Functional
Time	**8.42; (2, 35) *p*=.001**	**12.29; (2, 35) *p*<.001**
Subcategory	**23.36;(1, 35) *p*<.001**	**88.02; (1, 35) *p*<.001**
Format	1.42; (2, 35) *p*=.26	F<1; (2, 35)
Time x subcategory	1.05; (2, 35) *p*=.40	1.54; (2, 35) *p*=.17
Time x format	F<1; (4, 35)	1.02; (4, 35) *p*=.41
Format x subcategory	1.46; (2, 35) *p*=.20	F<1; (2,35)
Time x subcategory x format	1.65; (4, 35) *p*=.08	1.02; (4, 35) *p*=.44

Figure 7.11 Comparison of patient performance across time and category on the functional (left) and visual (right) picture sorting within subcategory tasks



Note: error bars denote standard error

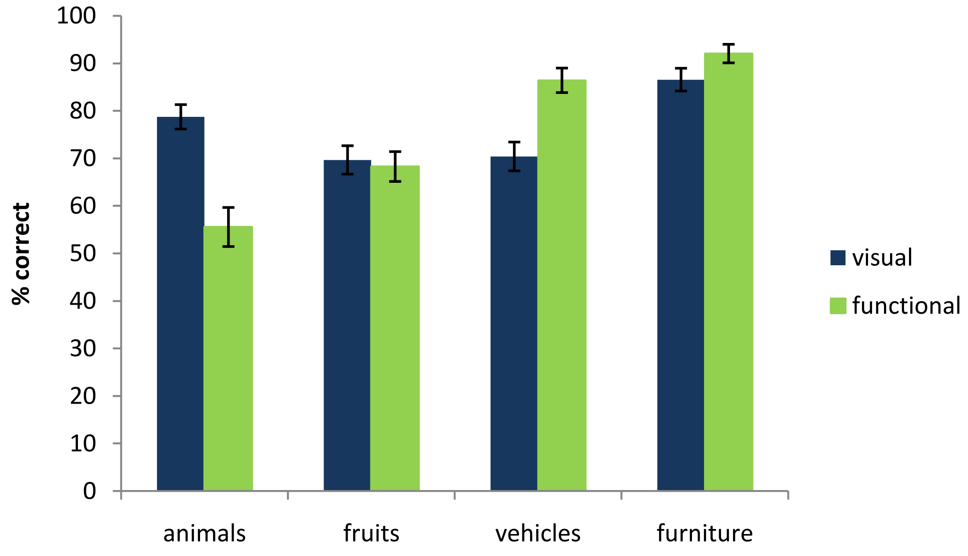
Figure 7.11 indicates participants consistently perform better with the nonliving subcategories on the functional task. However, on the visual task, there is no clear dissociation in performance across living and nonliving things. Thus, whether or not patients showed an advantage for a particular category differed according to the attributes which they were asked about. To explore this further, a three-way ANOVA was conducted to look at the interaction between time, attribute, and subcategory.

The results of this are presented in table 7.15. From this it is apparent that though there is no significant effect of attribute, this does interact significantly with subcategory.

Table 7.15 ANOVA results for patient performance; the interaction between time, attribute, and subcategory

	F-values
Time	**15.54; (2, 37) *p*<.001**
Subcategory	**73.65; (3, 37) *p*<.001**
Attribute	F<1; (1, 37)
Time x subcategory	1.39; (6, 37) *p*=.22
Time x attribute	F<1; (2, 37)
attribute x subcategory	**46.59; (3, 37) *p*<.001**
Time x subcategory x attribute	1.59; (6, 37) *p*=.15

Figure 7.12 Patient performance across subcategory on the visual and functional tasks (collapsed across time and format)



Note. Error bars denote standard error.

Though there was a significant main effect of time, this was not found to significantly interact with subcategory or format. As this would suggest, t-tests revealed the effect of attribute at each time point was fairly consistent. Thus, for animals, performance was significantly better on the visual than functional task at all time points (0 months: t= -6.41; p<0.001; 6 months: t=-4.93; p<0.001; 12 months: t=-4.71; p<0.001). By contrast, in regard to vehicles, performance was significantly better on the functional task at all time points (0 months: t=5.81; p<0.001; 6 months: t=2.81; p=0.01; 12 months: t=4.89; p<0.001). For fruits, performance was not found to differ significantly across attribute at any time point (0 months: t=-0.6; p=0.95; 6 months: t=1.19; p=0.24; 12 months: t=-1.4; p=0.17), whereas for furniture, performance was significantly better on the functional task at the first and second time points (0 months: t=2.33; p=0.03; 6 months: t=3.13; p=0.003; 12 months: t=1.42; p=0.16).

To explore the extent to which control performance influences interpretation of patient data, patient z-scores were calculated using the means and standard deviations from the control data, and the time by attribute, by subcategory three-way ANOVA recalculated replacing the patient scores with the z-scores. Using this approach, reanalysis of the data failed to show main effects for time, attribute, or subcategory, and there were no interactions between the variables.

Discussion

Concerning control performance at the subcategory level, it was not possible to analyse data from the dissimilar subcategory task as controls were 100% accurate across all time points and all formats. Analysis of the similar task performance revealed no significant effects of time, format, or category, and no interactions. By contrast, analysis of the patient data across both the similar and dissimilar tasks revealed a significant effect of category only when determining the subcategory to which similar concepts belonged, and a significant interaction between subcategory and level of similarity. Post hocs showed that this interaction may be attributed to differences in the effect of category. On the dissimilar task, patient performance was better with living things than nonliving things, though this did not reach significance. By contrast, on the similar task, patients performed significantly better with nonliving things. Further analysis of patient performance on the similar task using z-scores revealed a main effect of category only at the 12 month time point, and only when the images were presented as line drawings.

Picture-sorting tasks were also conducted to explore subordinate sorting in relation to visual and functional attributes. Analysis of control performance showed significant effects of time and subcategory across both the visual and functional tasks, and interactions between time, subcategory, and format on the functional task, and also time and subcategory, and attribute and subcategory when performance was compared across tasks. The effects of time noted were only found to relate to a significant increase with fruits between the second and third test sessions, which was observed on the functional task. Concerning the interaction between attribute and subcategory, post hoc analyses revealed that controls performed significantly better with animals on the visual task than on the functional task across all test sessions. By contrast, the opposite pattern emerged for vehicles, with performance being better on the functional task. For fruits and furniture, controls performed significantly better on the functional task, though only at the second time point (6 months).

Across both the visual and functional tasks, AD patients showed significant effects of time and subcategory, and a significant interaction between attribute (i.e. visual/functional task) and subcategory. Post hoc analyses relating to animals and vehicles revealed the same pattern of performance as was noted in controls. Performance was also better on the functional task for furniture, reaching significance at the first and second test sessions. By contrast, there was no difference across tasks for fruits. Interestingly, when these analyses were reconducted with z-score transformations of the patient data, there were no significant main effects or interactions.

7.4 GENERAL DISCUSSION

The main aim of this investigation was to conduct a longitudinal investigation of category-specificity in AD, with reference to healthy controls performing below ceiling. Though previously, cross-sectional data has been reported in which controls perform below ceiling (Whatmough et al., 2003), this is the first longitudinal study to present control data that is below ceiling across both living and nonliving things, and also to obtain data from controls at several time points rather than comparing longitudinal AD patient data to a single set of control data. In addition, performance was compared across format, to assess the extent to which surface information might influence category specific performance.

In relation to the effect of category, both patient and control groups performed worse with living things on the word-to-picture matching and naming tasks, though this was only significant for the latter, and only after the 6 month testing session, specifically, in those patients presented with the line drawings. Turning to the word -picture matching task first, any effect of category that might have emerged in controls is likely to have been masked by ceiling level performance in this group. The finding that the presence of a category effect in patient performance differed across these tasks, is consistent with previous research showing that the category specific deficit exhibited by AD patients on tasks of picture naming is not replicated using word-to-picture matching tasks (Hodges, Salmon, & Butters, 1992). Perhaps one explanation for this is that the word -picture matching task is one of the easiest semantic tasks (as suggested by the ceiling performance in controls and relatively good performance in patients). Indeed, as participants are provided with the name of the item, the participant needs only reasonably accurate information to match this name to the picture, and need know very little about the distracters to dismiss them. By contrast, the naming task requires the retrieval of specific knowledge about the depicted item to inform word retrieval and production. Consistent with this, research has shown that performance on word-picture matching tasks is relatively well preserved in patients with mild AD, and it is only late in the course of AD that patients begin to show a general deficit (Hodges & Patterson, 1995). In light of this, it is possible that even if AD patients' knowledge of living things is impaired, as the patients participating in this study were only mild AD patients (i.e. the mean MMSE of the patients in this study was equivalent to that of the mild AD group in the study by Hodges and Patterson), knowledge of living things would not be sufficiently impaired as to bring about a significant category effect.

The category effect for living things found to occur at all testing sessions on the naming task contradicts the predictions of the connectionist accounts (Gonnerman et al., 1997; Durrant-Peatfield et al., 1997), in that there was no crossover in patient performance with disease progression either from a living to nonliving impairment or vice versa. In addition, this is inconsistent with the findings of Gonnerman and colleagues (Gonnerman et al., 1997), who noted that AD patients were found to progress from a nonliving impairment to a living impairment, as a function of cognitive deterioration (determined by MMSE score). However, it is possible that the period of time over which participants were tested was not long enough, or the degradation of mental function not sufficient for a crossover effect to occur. Indeed, within this study, performance was only tested over a sixteen month period, using patients whose initial mean MMSE score was 22.13. By contrast, patients GP and NB, who were found to show a crossover in performance, were assessed over a minimum of two years (Gonnerman et al., 1997). In addition, the initial MMSE score of GP was 18, whilst that of NB was 21, deteriorating to 12 and 11 respectively. Thus, the level of degradation is likely to have been greater than that of the participants in the current study. Nevertheless, Garrard et al., (2001) also failed to find a crossover effect over a three year period in patients with comparable levels of semantic degradation to those used by Gonnerman et al., (1997). In addition, the current finding of worse performance with living things is consistent with the majority of longitudinal and cross-sectional studies conducted in this area (Garrard et al., 1998; Moreno-Martínez et al., 2008; Tippett et al., 2007; Whatmough et al., 2003; Zannino et al., 2002), which demonstrate a living thing impairment in AD patients at a similar level of impairment (according to MMSE scores) as those featured in this study.

Although AD patients were found to exhibit a significant category effect overall on the naming task, when compared to controls, patients were only found to be significantly impaired with living things when viewing the line-drawn versions of the images, and only from the 6 month session onwards. One explanation for this may be that as controls performance improved across testing sessions as a result of practice effects, whilst patients' performance deteriorated, this increased the difference between the groups, leading to the finding of a significant category effect. This would therefore have significant implications for longitudinal studies that compare patient performance over time to that of controls at a single time point (Garrard et al., 2001; Gonnerman et al., 1997; Moreno-Martínez, Laws, Goñi-Imízcoz, & Sánchez Martínez, 2008). Indeed, in doing so, it is possible that category effects may be missed. Moreover, if practice effects were more pronounced for a particular category of objects, this might then influence the emergent category effect in patients. Nevertheless, the current findings suggest that the effect of category observed may differ qualitatively, but not quantitatively from that of controls, and as such, is in keeping with the findings of several studies that have revealed that the living thing deficit found in patients is simply an exaggeration of the normal trend (Gale, Irvine, Laws, & Ferrissey, 2009; Moreno-Martínez & Laws, 2007, 2008; Moreno-Martínez, Laws, Goñi-Imízcoz, & Sánchez Martínez, 2008; Perri et al., 2003).

In addition to the finding that only subsequent to the 6 month testing session did a significant category effect for living things emerge in patients relative to controls, it is important to note that this was only found when using the line drawings. Several studies indicate that the presence of colour may be more important for the recognition of living things than that of nonliving things, as living thing items are typically more structurally similar, and have higher colour diagnosticity, than items from the nonliving domain (McRae, 1992; Price & Humphreys, 1989). Thus, the use of line drawings might have disadvantaged the recognition of living things to a greater extent, accounting for the deficit observed in AD patients, for items from this category. Zannino and colleagues (Zannino, Perri, Caltagirone, & Carlesimo, 2007) provide some support for this notion. They found that healthy controls and AD patients displayed a significant main effect of format, naming colour pictures of living things significantly better than line-drawn versions of the same images, and moreover, that when compared to controls, a significant deficit for living things only emerged in AD patients when naming the line-drawn images. Contrary to this however, within the current study, both controls and AD patients failed to show an effect of format, or a format by category interaction on all tasks. For controls, this contradicts the growing number of studies that have shown colour to be beneficial to object recognition in normative samples (Brodie, Wallace & Sharrat, 1991, experiment 3; Davidoff & Ostergaard, 1988; Humphrey, Goodale, Jakobson & Servos, 1994; Laws & Hunter, 2006; Price & Humphreys, 1989; Rossion & Pourtois, 2004; Tanaka & Presnell, 1999; Williams & Tanaka, 2000; Wurm et al., 1993). For the picture sorting and word -picture matching task, it is possible that the relative ease with which controls were able to perform these tasks would mask any effect of format, however it is not clear why an effect of format did not emerge on the naming task.

Concerning AD patient performance, though the failure to find an effect of format is inconsistent with the findings of Zannino et al (2007), it accords with more recent research conducted by Adlington, Laws, and Gale (in press)[18], which explored the influence of format and category on picture naming in 41 AD patients and 40 controls. Though the naming performance of controls improved linearly with the addition of surface detail, patients did not benefit from texture or colour information. Despite this, regression analyses revealed that for living things, format was a significant predictor of naming in AD. In addition, the study also explored whether AD patients exhibited cortical visual impairments. It was noted that AD patients displayed low-level visual impairments (i.e. deficits on shape discrimination, size discrimination, shape detection, and hue discrimination etc.), and moreover, that when entered into regression analyses, this predicted the naming of living but not nonliving things. It was reasoned therefore, that the recognition of living things is largely dependent upon the visual characteristics of the item, and that as a product of the low-level visual impairments observed in AD, patients were unable to use information relating to colour and texture to inform object recognition.

The notion that visual factors are more important for the recognition of living things than nonliving things is in part, supported by the findings of the third task used in this study. At the subordinate level, the picture sorting task required participants to sort items based on their attributes, specifically, either their visual or functional attributes. Four subcategories of items were included in this task; the living thing subcategories of animals and fruits, and the nonliving subcategories of vehicles and furniture.

[18] Chapter 6 of this thesis.

Interestingly, both patients and controls were found to perform better on the visual task when sorting between items from the ‘animals’ subcategory, and on the functional task when sorting items from the ‘vehicles’ subcategory, at all testing sessions. In addition, though not significant across all testing sessions, both patients and controls performed better on the functional task when sorting ‘furniture’ items. The pattern of performance obtained for ‘fruits’ was however inconsistent across participant groups, with controls performing better on the functional task, whilst patients showed no difference across the tasks. This would therefore suggest that certain subcategories of items differ in terms of how strongly they are associated with a particular attribute, and moreover, that those subcategories most strongly represented by visual attributes tend to be from the living domain whilst those most strongly associated with functional attributes tend to be from the nonliving domain. This is largely consistent with the sensory-functional account, which posits that the living things are more readily identified on the basis of visual features, whilst nonliving things are recognised on the basis of functional features (Warrington & McCarthy, 1987; Warrington & Shallice, 1984). Thus, it may be argued that given the low-level visual impairments that typically occur in AD, patients are more likely to show a deficit for living things as they are unable to process the visual information needed for the recognition of items from this category.

Though the findings of the picture sorting tasks offer some support for the sensory-functional account of category-specificity, they conflict with recent research evidence demonstrating that AD patients consistently perform better with items from the nonliving domain even when processing only concerns visual features (Duarte et al., 2009). One possible explanation for this inconsistency may be that the findings of this study could be an artefact of the questions asked. Indeed, it may be that the visual/functional questions differ in terms of relative difficulty. For example, the visual attributes used to sort between animals may be easier for the participant to conceptualise than the functional attributes. Nevertheless, this in itself may be further evidence that particular subcategories of items are more strongly associated with certain attributes, as it would follow that it would be easier to sort items based on the attributes with which they are more strongly associated.

In summary, this study supports previous longitudinal and cross-sectional studies in demonstrating a living thing deficit in patient performance, and moreover, does not support the predictions of those connectionist models of category-specificity, in which living and nonliving things differ according to the ratio of correlated: distinctive features, in that it fails to show a time-related crossover in the emergent deficit. Moreover, comparison of patient performance to that of controls suggests that the living thing impairment is simply an exaggeration of the normal trend, which may in part be the result of impaired low-level visual processing. Indeed, evidence from the visual-functional sorting task suggests that living things are more easily identified on the basis of their visual attributes, whilst functional attributes are more diagnostic of nonliving things. Thus, the low-level visual impairments previously noted in AD (Adlington, Laws, & Gale, in press; Cronin-Golomb, Gilmore, Neargarder, Morrison & Laudate, 2007; Cronin-Golomb, Sugiura, Corkin, & Growdon 1993; Gilmore, Cronin-Golomb, Neargarder, & Morrison, 2005a; Gilmore, Groth, & Thomas, 2005b; Kurylo et al., 1994; Pache et al., 2003; Rizzo, Anderson, Dawson, & Nawrot, 2000; Wijk, Berg, Sivik, & Steen, 1999) may prevent patients from processing the visual features advantageous in the recognition of living things.

Chapter 8: Do Category Specific Deficits Emerge in Alzheimer's Dementia when Patients are Referenced to Controls?

8.1 INTRODUCTION

Of the stimuli sets currently available, the largest, a databank of 260 line drawings with norms for name agreement, familiarity, image agreement, and visual complexity, is the Snodgrass and Vanderwart (SV) corpus (Snodgrass & Vanderwart, 1980). This has been used extensively to further understanding of perception and knowledge organisation; with normal subjects to explore object recognition (Dell'Acqua et al., 2000) naming (Pechmann & Zerbst, 2002) attention (Pashler & Harris, 2001) memory (Kohler et al., 2000) semantic priming (Damian, 2000), and to investigate the normal aging process (Ardila et al., 2000); with neuropsychological patients who display object recognition, semantic memory, and naming deficits (Berndt et al., 2002; Ousset et al., 2002; Ward & Parkin, 2000); and more recently in neuroimaging (Op de Beeck et al, 2000; Stark & Squire, 2000) and electrophysiological studies (Van Petten et al., 2000).

Of particular interest, is its use in studies of semantic category dissociations, in Alzheimer's dementia (AD) patients (Caramazza & Shelton, 1998; Gainotti, 2000). Using the SV corpus, investigations have revealed dissociations in the ability of AD patients to name items from the broad semantic categories of living and nonliving things (Caramazza & Shelton, 1998; Gainotti, 1998; Viggiano, 1998), with the majority reporting a deficit for living things (Chan et al., 2001; Fung et al., 2001; Gainotti et al., 1996; Gale, Irvine, Laws, & Ferrissey, 2009; Garrard et al., 2001; Garrard et al., 1998; Laws et al., 2005; Silveri et al., 1991; Silveri et al., 2002; Tippett et al., 2007; Zannino et al., 2002) though several also report deficits for nonliving things (Gonnerman et al., 1997; Tippett et al., 2007). This has led to the prevailing view that patients are more likely to exhibit impairments for living things, than for nonliving things. Contrary to this however, a recent meta-analysis of category-specificity in AD patients and controls (Laws, Adlington, Gale, Moreno-Martínez, & Sartori, 2007), revealed that the effect sizes obtained for living and nonliving things were comparable. Though this analysis was not solely based on studies using the SV corpus, the theories put forward to account for this finding related to control group and stimulus factors that are salient to the SV corpus and similar corpora.

Concerning control group factors firstly, Laws et al., (2007) suggested that one reason for the conflicting findings is that many studies rely on within-group comparisons or compare patients to controls who are performing at ceiling, which may distort both the degree and type of deficits reported for patients (Fung et al., 2001; Laws, 2005; Laws, Gale, Leeson, & Crawford, 2005). The frequency with which controls are found to perform at ceiling can be attributed to the widespread use of stimuli sets such as the SV corpus, which contain a majority of highly familiar, everyday items, easily named by healthy controls. In an attempt to counteract ceiling effects, researchers have identified statistical techniques, which compared to standard parametric tests, are better suited for use with data sets that are heavily skewed. Laws and co-workers (Gale, Irvine, Laws, & Ferrissey, 2009; Moreno-Martínez & Laws, 2007; 2008), have carried out a number of studies demonstrating how the bootstrap method may be applied in category specific research. Bootstrapping is useful as it requires far fewer assumptions about the distribution of the data than standard parametric tests and is suitable in circumstances where there is unequal variance across groups, or where there are multiple zero errors in performance (Delucchi & Bostrom, 2004). To conduct a bootstrap analysis, a relevant test statistic (F, t, r, etc.) is selected and calculated for n bootstrap samples (i.e. n permutations of the original data). If this occurs with replacement, a data point may be entered back into the sampling pool, and has the potential to be withdrawn numerous times. The result of this is a distribution of the test statistic, to which the original value (i.e. F, t, r, etc.) can be compared and declared statistically significant at the 0.05 level if, for instance, it is among the most extreme 5% of cases.

Using the bootstrap technique, recent research has called into question whether the category effect observed in AD patients is any greater than that observed in healthy elderly controls. Indeed, Moreno-Martínez and Laws (2007) noted that whilst a category deficit for living things was observed in AD patients, and persisted despite covarying out the effects of concomitant variables, this disappeared when referenced to controls using the bootstrapping method, indicating that the category effects observed in AD patients may simply be an exaggeration of the norm. Similarly, Moreno-Martínez and Laws (2008) used this technique to demonstrate that elderly healthy controls displayed the same significant advantage for nonliving things across three semantic tasks, as did AD patients. These findings therefore suggest that category effects do exist in AD, but to no greater extent than might be expected based on the performance of healthy elderly controls. Moreover, concerning normal performance, this highlights the fact that a *normal* advantage for nonliving things may previously have been masked by ceiling effects. This is consistent with recent research that has incorporated low frequency items as a means to avoid ceiling level performance in controls (Adlington, Laws, & Gale, 2009; Coppens & Frisinger, 2005).

The meta-analysis conducted by Laws et al (2007a) also demonstrated that stimulus factors, and image format in particular, may influence the emergence and direction of category specific effects in AD patients. In recent years, a number of normative investigations have shown that surface details such as colour and texture, may be important for object naming (Brodie, Wallace & Sharrat, 1991, experiment 3; Davidoff & Ostergaard, 1988; Price and Humphreys, 1989; Rossion & Pourtois, 2004; Tanaka & Presnell, 1999; Williams & Tanaka, 2000; Wurm et al., 1993). Of interest within the field of category-specificity however, are several findings that suggest objects with high structural similarity and colour diagnosticity, may be more readily influenced by the presence or absence of colour. This is because these qualities are typically attributed to living things (Gaffan & Heywood, 1993; Gale, Done, & Frank, 2001; Humphreys et al., 1988, 1995; McRae, 1992), thus, the predominant use of line drawings taken from the SV corpus may automatically disadvantage recognition of items from the living domain. If AD participants are influenced by image format in the same way as healthy individuals, the reliance on line drawings might account for the prevalence of living thing cases reported in the literature.

Though normative data, for colour and greyscale versions of the SV items is now available (Rossion & Pourtois, 2004), little research has been conducted to explore the influence of surface detail on picture naming in AD, and those that do have used other stimuli sets (e.g. Montanes, Golblum, & Boller, 1995; Zannino, Perri, Caltagirone, & Carlesimo, 2007). Nonetheless, there is some evidence to support the notion that the higher incidence of living thing deficits may be attributed to the use of line-drawn stimuli. Using colour and line-drawn versions of the same living and nonliving items, Zannino et al., (2007) found that both AD patients and healthy controls were able to name living things significantly better when they were presented in colour than as line drawings. In addition, when referenced to control performance, the living thing deficit exhibited when AD participants viewed the line-drawn stimuli, disappeared when the items were presented in colour.

In contrast to the findings of Zannino et al. (2007), recent findings from the meta-analytic review conducted by Laws and co-workers (2007a) suggest that colour may not be beneficial to object naming in AD patients. Conversely, they reported that a significantly larger effect size emerged for living things when items were presented in colour, than when they were presented as line drawings, though there was no difference in the effect sizes obtained for nonliving things. Thus, this suggests that AD performance is actually worse with colour than line-drawn images. This was attributed to the visual impairments common to this group of patients (Cronin-Golomb, Sugiura, Corkin, & Growdon 1993; Kurylo et al., 1994; Pache et al., 2003; Rizzo, Anderson, Dawson, & Nawrot, 2000; Wijk, Berg, Sivik, & Steen, 1999), in that whilst controls may benefit from colour information, patients are unable to use this information, thus increasing the difference in performance between patients and controls. As the effect sizes were larger for living than nonliving things, it is possible that the predominant use of line drawings may account for the high incidence of living thing deficits reported in the literature.

Through the preceding discussion, it is apparent that the findings of the meta-analysis conducted by Laws and colleagues (2007) may have important implications for the continued widespread use of the SV corpus, and indeed other stimuli sets that contain line-drawn images of familiar objects that promote ceiling performance in controls. However, to the author’s knowledge, there are no papers that directly compare the performance of AD patients and controls across items obtained from the SV corpus, to that of performance obtained on another corpus. Thus, the aim of this chapter was to explore AD patient performance in reference to controls using the SV corpus, and also a novel set of stimuli, the Hatfield Image Test (HIT: Adlington, Laws, & Gale, 2009), on which control performance is well below ceiling. This was designed to explore the extent to which control performance might ultimately influence the pattern of performance documented in AD patients. A further advantage to using the HIT was that images are available in colour, greyscale, and line-drawn formats. Thus, using the coloured and greyscale versions of the SV items developed by Rossion and

Pourtois (2004), we were able to explore the influence of format on AD patient and control naming across the two image sets.

8.2 METHOD

8.2.1 Participants

Data were obtained from (i) 38 patients (21 females, 17 males; mean age = 80.81; SD =6.67) with probable AD, diagnosed at the memory disorders clinic at the QEII hospital according to NINCDS-ADRDA criteria. Control data for the HIT and for the line-drawn versions of the SV stimuli were obtained from 47 age matched controls (23 females, 24 males; mean age = 78.47; SD =4.55; F=3.64; p=.06) the majority of whom were taken from the community though approximately a quarter were the spouses of patients participating in the study. For the colour and greyscale versions of the SV, control data from an earlier investigation was used. This was obtained from a sample of 52 healthy elderly participants (26 females, 26 males; mean age =79.71; SD = 7.07), whose mean age was equivalent to that of the patients (F= .55; p=.46) and controls (F= 1.06; p=.31) employed in the current study. All participants had normal or corrected-to-normal vision, and spoke English as a first language.

8.2.2 Materials

Colour, greyscale and line-drawn versions of the 147 items from the HIT corpus (Adlington, Laws, & Gale, 2009) and of 100 items from the Snodgrass and Vanderwart corpus (1980) were used in this study. Regarding the HIT items, 61 were taken from the living thing subcategories of animals, birds, body parts, flowers, fruits, insects and vegetables, and 86 from the nonliving subcategories of buildings, clothes, food, furniture, kitchen utensils, musical instruments, tools, and vehicles. Of the Snodgrass and Vanderwart items, 50 were taken from the living thing subcategories of animals, birds, body parts, fruits and vegetables, and 50 were taken from the nonliving subcategories of clothes, furniture, musical instruments, tools, and vehicles. All images were presented on a laptop computer, using the TestBed (version 1.0) software.

8.2.3 Design & Procedure

All participants completed a naming task in which they were presented with colour, greyscale or line-drawn versions of the HIT. All patients, and those controls that were presented with the line-drawn versions of the HIT, were asked to complete this task with the SV items also (format was consistent across the HIT and SV sets). Each set of items was presented separately, with a rest period between them, and the order of presentation was randomised. The presentation of the items within each set was also randomised. Images were presented on a laptop computer using the Testbed (version 1.0) software. Each image was preceded by a cross (+) for 500ms, and after a brief blank screen (150ms), was presented on screen until the participant responded. Participants were asked to name each image as briefly and unambiguously as possible, by saying aloud only one name, though the name itself could consist of more than one word. Participants were asked to say ‘don’t know’, if the image was unknown to them, or to say ‘tip of the tongue’ if they were momentarily unable to remember the name. Their responses were recorded by the experimenter.

The participants’ response was accepted as correct in instances where an item could legitimately be referred to by more than one name (e.g. spaghetti spoon/pasta spoon, chicken/hen), or when the name of a visually similar item was given (e.g. cabbage/lettuce, cello/double bass). In addition, items that were named at a more specific level (e.g. ‘springbok’ for ‘antelope’; ‘trilby’ for ‘hat’) were taken as correct when the name given was appropriate for the representation of the item.

8.3 RESULTS

Analyses were carried out by subjects (F_1), and by items (F_2). For analyses carried out across subjects, participants were matched across format for age, sex, and for patients, MMSE score (see table 8.1). For the patients, corpus (i.e. HIT v Snodgrass and Vanderwart items) was a repeated measure. For controls, corpus was only repeated for the line-drawn items. Nevertheless, for the greyscale and colour conditions control participants were matched across corpus for those variables noted above. For the by items analyses, the HIT and Snodgrass and Vanderwart set were matched across category for the effects of age of acquisition, familiarity, name agreement, visual complexity, and word frequency. In addition to the F_1 and F_2 analyses, we also calculated the *minF'*statistic (Clark, 1973), to obtain an overall measure of significance, treating subjects and items as dependent variables within one analysis.

Table 8.1 Demographic information for patients and controls

		Colour	**Greyscale**	**Line**	**ANOVA**
Age	AD patients	82.60 (5.97)	79.00 (7.51)	80.08 (6.8)	F<1
	Controls	79.52 (6.68)	79.36 (4.87)	76.9 (6.14)	F=1.01; p=0.37
	ANOVA	*F=2.57; p=0.11*	*F<1*	*F=1.49; p=0.24*	
Education (years)	AD patients	11.60 (3.42)	10.9 (2.8)	10.83 (2.36)	F<1
	Controls	11.05 (2.11)	12.64 (3.58)	12.38 (1.50)	F=1.99; p=0.15
	ANOVA	*F<1*	*F=1.62; p=0.22*	*F=3.89; p=0.06*	
MMSE	AD patients	21.2 (5.92)	22.5 (5.82)	23.42 (3.85)	F<1

8.3.1 Does naming performance on the hit correlate with that for the SV corpus?

Pearson's correlation analyses were initially conducted to determine whether the pattern of naming performance obtained for the HIT was related to that obtained using the SV corpus. Analysis of normative naming performance across the two image sets revealed a nonsignificant correlation (r=-.48; p>0.05). By contrast, when the same analysis was conducted for patients, this revealed a significant positive correlation (r=.88; p<0.01). One potential explanation for the difference across patients and controls may be the ceiling level performance noted in controls. Indeed, as normative naming performance on the HIT is normally distributed, performance on items from this set may continue to increase when performance with the SV set has reached ceiling, thus also accounting for the negative correlation in normative naming performance across the two sets.

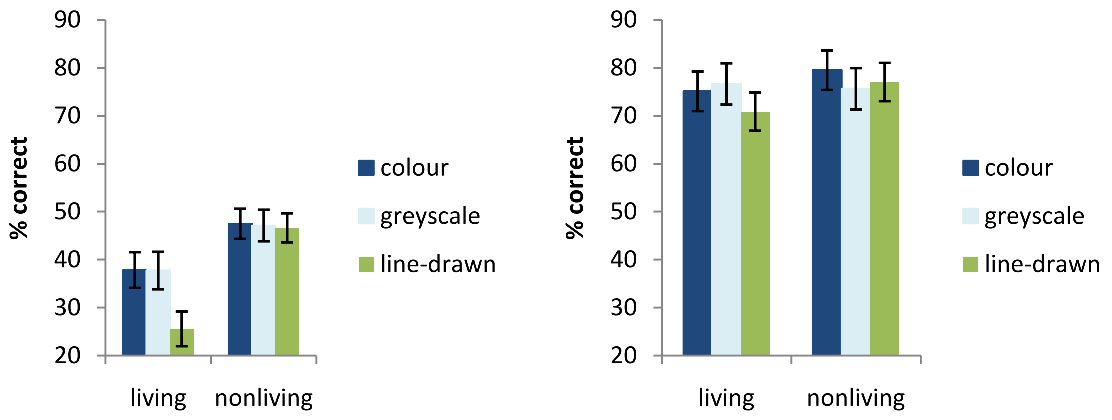
8.3.2 Analyses of AD patient naming: corpus x category x format

As table 8.2 shows, a three-way ANOVA revealed a significant main effect of category, and corpus, but no effect of format. There was however, a significant interaction between category and format, though no interaction between category and corpus. There was no overall interaction between corpus, category, and format.

Table 8.2 Results of a three-way ANOVA to explore the influence of category, corpus, and format on picture naming in AD patients

	F_1	F_2	*minF'*
Category	**41.99 (1, 34) *p*<0.001**	**5.20 (1, 243) *p*=0.02**	**4.63 (1, 277) *p*<0.03**
Corpus	**1288.21 (1, 34) *p*<0.001**	**95.09 (1, 243) *p*<0.001**	**88.55 (2, 270) *p*<0.001**
Format	0.43 (2, 34) *p*=0.66	**24.25 (2, 243) p<0.001**	0.42 (2, 35) *p*=0.66
Category x corpus	**31.07 (2, 34) *p*<0.001**	1.96 (2, 243) *p*=0.16	1.84 (2, 267) *p*=0.16
Category x format	**4.61 (2, 34) *p*=0.02**	**10.78 (2, 243) *p*=0.001**	**3.23 (2, 68) *p*<0.05**
Corpus x format	2.02 (2, 34) *p*=0.15;	2.53 (2, 243) *p*=0.11	1.12 (2, 101) *p*=0.33
Category x corpus x format	1.63 (2, 34) *p*=0.21	2.86 (2, 243) *p*=0.06	1.04 (2, 80) *p*=0.36

Figure 8.1 AD patient performance on the HIT (left) and SV (right) across category and format



Note: error bars denote standard error

As anticipated, patients performance was significantly worse with items from the HIT than with items from the SV (t=-35.73; p<0.001), with mean performance being 75.76% compared to 40.37% on the SV and HIT respectively. Figure 8.1 shows that patients exhibit a deficit for living things. Post hoc analyses revealed this to be significant overall, for both the HIT (t=-7.94; p<0.001), and the SV (t=-2.27; p<0.05). However, as table 8.3 shows, when the effect of category was calculated for each format, a significant deficit for living things was only found on the HIT, and only when the items were presented in line-drawn format.

Table 8.3 One-way ANOVA to explore category naming in AD patients, across each format and stimulus set.

	HIT			*SV*		
	Living Mean (SD)	*Nonliving Mean (SD)*	*F (df=1, 146)*	*Living Mean (SD)*	*Nonliving Mean (SD)*	*F (df=1, 99)*
Colour	37.81 (32.13)	47.44 (31.81)	3.24	75.07 (25.12)	79.47 (23.44)	0.82
Greyscale	37.71 (33.44)	47.09 (33.11)	2.85	76.60 (27.67)	75.60 (23.75)	0.04
Line-drawn	25.55 (28.78)	46.61 (29.66)	18.44***	70.83 (28.23)	77.00 (24.14)	1.38

***p<0.001

Regarding the interaction between format and category, the effect of format was significant for nonliving things only when using the SV corpus, with naming being significantly better when items were presented in colour than when they were presented in greyscale (t=2.3; p<.05). There were also significant effects of format for the SV corpus for living things. Specifically, patients were significantly better with the colour images than the line-drawn (t=2.06; p<0.05), and with the greyscale images than the line-drawn (t=3.03; p<0.01). Finally, when using the HIT, the only significant effects of format emerged for the living things, with patients performing better with the colour than the line-drawn (t=5.04; p<0.001), and better with the greyscale than the line-drawn images (t=4.75; p<0.001).

8.3.3 Analysis of control performance: category x format

Owing to the fact that control data was obtained using a mixed measures design, with different subjects seeing the SV and HIT stimuli sets, this was analysed using separate two-way ANOVAs to explore control performance on the HIT and SV independently. Nevertheless a pairwise comparison of naming across the two stimuli sets revealed that performance overall was significantly better for the SV items than the HIT (F (1, 246) = 62.44; p<0.001), with mean performance on the SV items being at ceiling (L=91.97 (SD= 12.2); NL=93.74 (SD=9.18)).

Table 8.4 shows that analysis of performance on the HIT, revealed a significant effect of category. However, there was no main effect of format and no interaction between category and format. By comparison on the SV corpus (table 8.5), there was no effect of category, or of format, and no interaction between category and format.

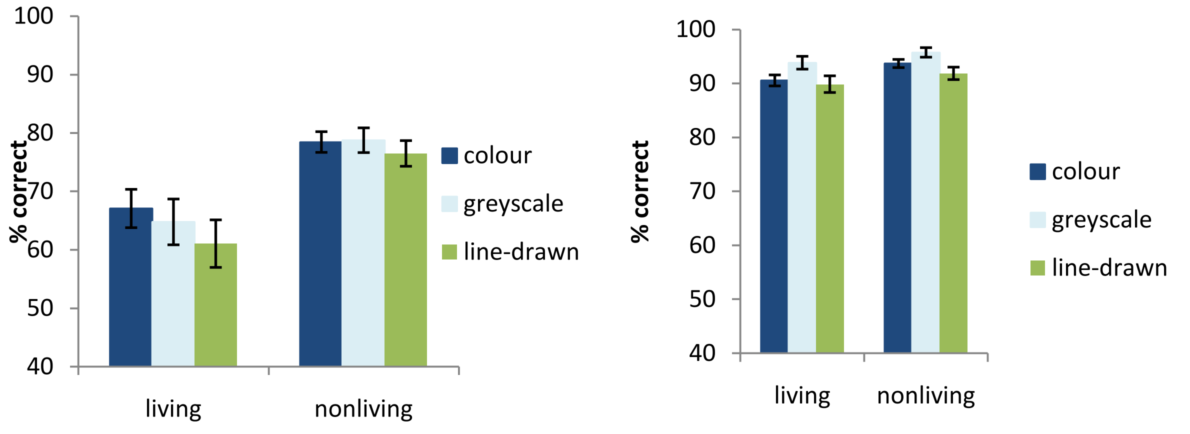
Table 8.4 Results of a two-way ANOVA to explore the effects of category and format on controls naming items from the HIT corpus

	F_1	F_2	*minF'*
Category	**77.55 (1, 44) *p*<0.001**	**11.76 (1, 145) *p*=0.001**	**10.21 (1, 175) *p*<0.01**
Format	0.57 (2, 44) *p*=0.57	**12.47 (2, 145) p<0.001**	0.55 (2, 48) *p*=0.58
Category x format	0.65 (2, 44) *p*=0.53	1.29 (2, 145) *p*=0.27	0.43 (2, 92) *p*=0.66

Table 8.5 Results of a two-way ANOVA to explore the effects of category and format on controls naming items from the SV corpus

	F_1	F_2	*minF'*
Category	**17.61 (1, 62) *p*<0.001**	0.67 (1, 98) *p*=0.42	0.64 (1, 105) *p*=0.42
Format	**3.82 (2, 62) *p*<0.05**	**3.23 (2, 98) p<0.05**	1.75 (2, 157) *p*=0.18
Category x format	0.64 (2, 62) *p*=0.53	0.56 (2, 98) *p*=0.57	0.27 (2, 149) *p*=0.76

Figure 8.2 Control performance on the HIT (left) and SV (right) stimuli sets, across category and format



Note: error bars denote standard error

Figure 8.2 shows that across both stimuli sets, controls performed better with nonliving things, though this only reached significance on the HIT corpus. The main effect of category observed using the HIT was consistent across the colour (t= -4.65; p=0.001), greyscale (t=-5.79;p<0.001) and line-drawn (t=-4.99; p<0.001) items. By contrast, there was no main effect of category on the SV items, most probably due to performance being at ceiling on this corpus, therefore preventing the emergence of a significant effect of category. Indeed, post hoc analyses revealed that whilst no overall effect of category emerged, there was a significant effect of category when the images were presented as line drawings ($t=-4.46$; $p<0.001$), but not when they were presented in greyscale ($t=-2.02$; $p=.06$), or colour format ($t=-1.49$; $p=.16$). For this reason, the control data was reanalysed across category for each format, using the bootstrapping technique.

8.3.4 Bootstrap Analyses

Given that naming performance in controls reached ceiling on the SV corpus, bootstrap analyses were conducted as these make fewer assumptions about the distribution of the data (e.g. Delucchi & Bostrom, 2004). Separate analyses were carried out to explore category effects across each format. Though performance did not reach ceiling on the HIT, bootstrap methods were also used to reanalyse this data. Table 8.6 shows the findings of the bootstrap analyses carried out to explore naming across category in control participants. From this, it appears that the findings of the bootstrap are predominantly consistent with those of the previous analyses in that a category effect emerges with the HIT items, but not with the SV items. However, the t-tests reported for the SV corpus revealed a significant category effect for the line-drawn images that was not replicated in the bootstrap analyses.

Table 8.6 Bootstrap analyses to explore category naming in controls

	SV (df=1, 99)			HIT (df = 1, 146)		
	ANOVA	LT M [95%CI]	NLT M [95%CI]	ANOVA	LT M [95%CI]	NLT M [95%CI]
Colour	F=1.09; p>.05	91.51 [87.13 to 95.30]	91.82 [87.13 to 95.32]	**F=9.59; p<.05**	70.62 [64.64 to 76.15]	81.25 [76.64 to 85.11]
Greyscale	F=1.81; p>.05	93.83 [90.23 to 96.67]	95.73 [92.77 to 98.02]	**F=10.68; p<.05**	62.95 [55.66 to 69.83]	76.5 [70.99 to 81.99]
Line-drawn	F=2.08; p>.05	90.66 [86.14 to 95.3]	93.61 [90.18 to 96.38]	**F=12.95; p<.05**	61.85 [54.41 to 68.8]	76.9 [71.34 to 82.42]

Note. LT M= living things mean % correct; NLT M= nonliving things mean % correct.

8.3.5 Does AD patient performance across category differ when referenced to controls?

Previous studies have shown that patient performance may differ substantially when referenced to that of controls. To determine whether the category effects noted above differed when patients are referenced to controls, two methods were used; (i) converting patient scores to z-scores and analysing the data using a two-way ANOVA, and (ii) covarying control performance in a bootstrap ANOVA. These were used to explore patient naming across category on the HIT and SV. For each corpus, performance across category was analysed separately for the colour, greyscale, and line-drawn versions.

Analysis of patient performance referenced to controls: z-scores

Table 8.7 Comparison of z-scores across living and nonliving things

	HIT		SV	
	Mean z-scores	**(df = 1, 146)**	**Mean z-scores**	**(df = 1, 99)**
Colour	-1.49	F = 3.24; p=.07	-1.00	F=.82; p=.37
Greyscale	-1.01	F= 2.85; p=.09	-1.73	F=.04; p=.85
Line-drawn	-1.19	F=18.44; p<0.001	-1.31	F=1.38; p=.24

Table 8.7 shows that using z-scores to compare patient naming to that of controls reveals the same pattern of performance as when patients were not referenced to controls, specifically, a significant deficit for living things only emerged when viewing the line-drawn versions of the HIT.

Analysis of patient performance referenced to controls: controls as a covariate

When control performance was entered as a covariate in a bootstrap ANOVA, the effect of category failed to reach significance. As table 8.8 shows, this was true for both stimuli sets across all formats.

Table 8.8 Bootstrap analyses to explore category naming in patients when covarying control performance

	SV (df=1, 99)			HIT (df = 1, 146)		
	ANOVA	LT M [95%CI]	NLT M [95%CI]	ANOVA	LT M [95%CI]	NLT M [95%CI]
Colour	F=0.33; p>.05	74.75 [68.00 to 81.23]	78.68 [72.39 to 84.8]	F=1.42; p>.05	44.28 [35.96 to 51.82]	42.38 [36.12 to 48.2]
Greyscale	F=2.00; p>.05	77.59 [70.66 to 84.5]	74.03 [67.51 to 80.43]	F=1.47; p>.05	43.99 [35.97 to 52.05]	41.64 [35.32 to 47.68]
Line-drawn	F=1.37; p>.05	72.29 [65.23 to 78.52]	74.71 [68.38 to 80.36]	F=7.43; p>.05	32.48 [26.37to 38.91]	41.45 [36.08 to 46.62]

Note. LT M= living things mean % correct; NLT M= nonliving things mean % correct.

8.3.6 Summary of Findings

Comparison of picture naming in AD patients and controls across the SV and HIT items revealed that both patients and controls performed significantly better overall with items from the SV corpus, with controls performing at ceiling on the SV corpus. Regarding control performance firstly, participants consistently showed an advantage for nonliving things. This was significant across all formats for the HIT, and remained so when analysed using the bootstrapping method. By contrast, controls only showed a category effect on the SV corpus when images were presented as line drawings. This effect failed to emerge when analysed using the bootstrapping method. Controls showed no main effect of format and no format by category interaction.

Analysis of absolute differences in patient naming performance, revealed significantly worse performance with living things across both the HIT and SV stimuli, though post hoc analyses showed that this was only significant when patients named the line-drawn versions of the HIT. Whether this category effect persisted when referenced to controls depended on the methods used. When patient scores were converted to Z-scores, the effect of category for the line-drawn versions of the HIT remained. However, when control performance was covaried in a bootstrap analysis, the effect of category failed to reach significance.

Analysis of AD naming performance revealed a significant interaction between format and category. When presented with the HIT items, there was no effect of format for nonliving things, though performance with living things improved linearly with the addition of surface detail. This pattern of performance for living things was also observed with the SV stimuli. In addition, nonliving things were named significantly better in colour than in greyscale, though there were no other significant differences across format.

8.4 GENERAL DISCUSSION

The main aim of this investigation was to explore the extent to which the use of within-group comparisons and ceiling level performance in controls may influence the emergence of category specific deficits in AD patients. Given that control naming performance on the Snodgrass and Vanderwart (1980) corpus of images is typically at or near ceiling, AD patient and control naming performance on this, was compared to that obtained using the HIT corpus, on which control naming approximates a normal distribution, to explore whether differences were observed across stimuli sets. In addition, as the SV and HIT stimuli sets are available in colour, greyscale, and line-drawn formats, the effects of format, and the interaction between format and category were analysed.

Overall, the findings showed that both patients and controls named fewer living than nonliving things on both the HIT and SV stimuli sets. Concerning controls, a category effect was found across all formats on the HIT corpus, but only for the line-drawn versions of the SV corpus. Using the bootstrapping technique, no effect of category emerged in controls on the SV corpus. Based on absolute differences in performance, patients also showed a main effect of category, though post hoc analyses revealed that this was significant only for the line-drawn versions of the HIT. When AD performance was compared to that of controls, the effect of category previously found persisted when converted to z-scores, but not when analysed with control performance as a covariate. Image format was not found to influence the performance of controls, though analysis of patient data revealed a significant category by format interaction, with the addition of surface detail having a greater impact on the naming of living things.

Comparison of overall patient and control performance revealed that both groups scored significantly higher on the SV stimuli than the HIT, with the mean correct for controls being 91.97% (SD=12.2) and 93.74% (SD=9.18) for living and nonliving things respectively, thus exhibiting ceiling level performance. Therefore, it is perhaps to be expected that whilst controls performed worse with living things across both stimuli sets, this only reached significance for the HIT corpus. By contrast, patients were found to name significantly fewer nonliving items across both the HIT and SV sets. However, post hoc analyses revealed that the effect of category was only significant for the HIT corpus, and only when the images were presented as line drawings. This finding will be discussed in more detail in conjunction with the effects of format, later in the discussion. When compared to controls, a deficit for living things persisted when patient scores were converted to z-scores based on the means and standard deviations of controls, though not when control scores were entered into a bootstrap ANCOVA as a covariate. This is largely consistent with the findings of Moreno-Martínez and Laws (2008), who found that whilst within-group comparisons of AD naming data revealed a significant deficit for living things, this was not found when referenced to controls. In addition, their study revealed that comparison of living and nonliving things within-group, to obtain effect sizes for patients and controls, revealed larger effect sizes for controls than for patients. The finding of Moreno-Martínez and Laws (2008), as well as those of the current study, therefore support the notion that the category specific deficit observed in AD patients may differ quantitatively, but not qualitatively from that of controls.

Ceiling level performance in controls was not found to influence the emergence of a category effect in AD patients, though this may be due to the fact that AD patients did not exhibit a category specific deficit for living things on the SV stimuli when only within-group performance was analysed.

Nevertheless, it is important to note that controls failed to exhibit a category effect when performing at ceiling, but did so when performance was below ceiling. This demonstrates how ceiling effects may mask category specific effects in controls, which not only has important methodological implications, as discussed previously, but also theoretical implications. Indeed, the finding that a nonliving advantage is the norm poses problems for several accounts of category-specificity. For example, the connectionist accounts of category-specificity (Gonnerman, Andersen, Devlin, Kempler, & Seidenberg, 1997; Moss, Tyler, Durrant-Peatfield, & Bunn, 1998) and the sensory-functional account (Warrington & McCarthy, 1983) do not make any predictions about category effects in neurologically intact individuals. Similarly, though the artefactual account (Funnell & Sheridan, 1992; Stewart, Parkin, & Hunkin, 1992) would predict a nonliving advantage in controls, this would not be expected to occur when stimuli are matched across category for important nuisance variables. Furthermore, though the domain-specific hypothesis (Caramazza & Mahon, 2003; Caramazza & Shelton, 1998; Mahon & Caramazza, 2003) does not make any explicit predictions about normative performance, it may arguably condone a normal living advantage, because if specialised neural systems exist for the recognition of these items, then it follows that living things should be recognised more quickly than nonliving things. Therefore, the finding of a nonliving advantage in healthy controls is problematic for many theories of category-specificity, and highlights the importance of exploring category effects in healthy controls, using images on which performance is below ceiling.

The use of the Rossion and Pourtois (2004) images, which provide greyscale and colour depictions of the SV stimuli, allowed exploration of the interaction between format and category across the two stimuli sets. Concerning patient data first of all, across both stimuli sets there was a significant interaction between format and category. On the HIT corpus, the naming of living things was found to improve linearly with the addition of surface detail, though there was no effect of format for nonliving things. On the SV corpus, performance with items from the living domain again improved linearly with the addition of surface detail, however in addition to this, nonliving things were named significantly better when presented in colour than when presented in greyscale. That living things benefitted more than nonliving things from the addition of surface detail is consistent with several studies showing that colour is more important when items are structurally similar, and have high colour diagnosticity, characteristics typically attributed to living things (McRae, 1992; Price & Humphreys, 1989). In addition, the finding that AD patients benefit from the presence of surface detail corroborate recent findings showing that AD patient naming performance improved with the addition of surface detail, and that although this occurred across both categories, the effect of format was greater for living things (Zannino, Perri, Caltagirone, & Carlesimo, 2007). Moreover, they also found that a significant effect of category was only observed when items were presented as line drawings, which accords with the findings for the HIT corpus in the current study. It was argued that as colour is more important for the recognition of living things, the absence of this may create a disadvantage for this category, thus exaggerating the category effect. Given that line drawings are typically employed in category specific research, this may account for the prevalence of living thing deficits reported in the literature.

Though the effect of format displayed by AD patients in the current investigation is consistent with the findings of previous research, it is at odds with the findings of the meta-analysis conducted by Laws and colleagues (Laws et al., 2007) which reported larger effect sizes for both living and nonliving things when the items were presented in colour, compared to when they were presented as line drawings. Moreover, they noted that this difference was significant for living things, therefore suggesting that AD patients actually perform worse with living things when they are presented in colour, than when they are presented as line drawings. To account for this, they alluded to research that has found that AD patients display impaired colour processing (Cronin-Golomb, Sugiura, Corkin, & Growdon 1993; Kurylo et al., 1994; Pache et al., 2003; Rizzo, Anderson, Dawson, & Nawrot, 2000; Wijk, Berg, Sivik, & Steen, 1999). Specifically, they argued that as controls performance improves with the presence of colour (Brodie, Wallace & Sharrat, 1991, experiment 3; Davidoff & Ostergaard, 1988; Humphrey, Goodale, Jakobson & Servos, 1994; Laws & Hunter, 2006; Price & Humphreys, 1989; Rossion & Pourtois, 2004; Tanaka & Presnell, 1999; Williams & Tanaka, 2000; Wurm et al., 1993), the inability of AD patients to make proper use of colour information would increase the discrepancy in performance between patients and controls, thus resulting in large effect sizes for colour stimuli. Furthermore, given that the naming of living things is generally thought to benefit more from the presence of colour than nonliving things (McRae, 1992; Price & Humphreys, 1989), the effect would be greater for this domain. The findings of the current study therefore conflict with this as, contrary to prediction, AD patients were found to benefit from the presence of colour.

In contrast to the effect of format observed in AD patients, no effect of format was observed in controls. Though this is consistent with a small number of studies that failed to find an effect of format on object recognition (Biederman & Ju, 1988; Davidoff & Ostergaard, 1988; Ostergaard & Davidoff, 1985; Price & Humphreys, 1989), it nevertheless conflicts with a large number of studies demonstrating an effect of format on the object naming accuracy of healthy controls (Brodie, Wallace & Sharrat, 1991, experiment 3; Davidoff & Ostergaard, 1988; Humphrey, Goodale, Jakobson & Servos, 1994; Laws & Hunter, 2006; Price & Humphreys, 1989; Rossion & Pourtois, 2004; Tanaka & Presnell, 1999; Williams & Tanaka, 2000; Wurm et al., 1993). Concerning performance on the SV corpus, it is likely that any effect of format would have been masked by ceiling level performance since, given that controls were already performing at ceiling with the line drawings, this limits the extent to which performance may improve. By contrast, it is unclear why there was no effect of format on the recognition of items from the HIT corpus. Nevertheless, it is interesting to note that an effect of format also failed to emerge in chapter 4, when the entire corpus was used, though when a reduced subset of items was used in chapters 5 and 6, an effect of category emerged. One possible explanation for this therefore may be that whether an effect of format emerges may be an artefact of the items used. Specifically, the subset of items used in chapters 5 and 6 had a lower overall mean familiarity rating and word frequency rating than that of the corpus as a whole. Thus, it is possible that colour may be more important for object recognition when items are less familiar or less common, as in these instances the presence of colour may be more useful in informing object identification. Nevertheless, this remains a tentative suggestion, and one that requires further research.

In summary, the findings of this chapter demonstrate that failing to use control data, or using controls that are performing at ceiling may have important methodological and theoretical implications for category specific research. In addition, concerning the role of format in object recognition, it highlights the need for further research to explore the factors that may influence the extent to which colour may be beneficial in object naming, and also whether the presence of colour impacts upon the performance of patients with Alzheimer's dementia.

Chapter 9: A Meta-analytic Study of Category Specific Naming in Alzheimer's Dementia Patients and Controls: A Comparison of the Snodgrass and Vanderwart (1980) Corpus and Other Corpora.

9.1 INTRODUCTION

As mentioned in chapter 8, a recent meta-analysis of category specific naming in Alzheimer's dementia (AD) patients and healthy controls revealed that contrary to the prevailing view that living thing deficits occur more commonly in AD patients, the effect sizes obtained for living and nonliving things were in fact comparable (Laws et al., 2007). It was argued that the frequent use of within-group comparisons or use of controls performing at ceiling might account for this discrepancy, as both have been shown to distort both the degree and type of category specific impairment found in AD (Fung et al., 2001; Laws, 2005; Laws, et al., 2005).

The experiment reported in chapter 8 provides some support for the argument put forward by Laws and colleagues (2007) as this showed how when referenced to controls using the bootstrap method, the living deficit previously observed when analysed via within-group comparison, failed to emerge. Analyses also revealed however, that whether or not controls were performing at ceiling did not influence findings. One potential explanation for this is that on the Snodgrass and Vanderwart (1980) images (SV), post hoc analyses failed to show significant category effects in patient performance. Therefore, it is unlikely that a category effect would then emerge when referenced to controls. To explore the effect of ceiling effects and within-group comparisons further, it was thus decided to run a meta-analysis to compare the effect sizes obtained for living and nonliving things using stimuli at ceiling, to those that were not. Specifically, given that performance with the SV corpus is typically at ceiling, it was decided that a comparison would be made between those studies using the SV corpus, and those using other corpora (non-SV)[19].

[19] Though several of the studies using stimuli other than the SV set (non-SV studies) reported controls who were scoring above 90% correct across both living and nonliving things, there were nonetheless, far fewer than

9.2 METHOD

An electronic article search for studies of category-specificity in AD was conducted using Web of Science and Science Direct. Studies were identified using the key words ‘Alzheimer’s’, ‘category specific*’, and ‘naming’. The year of publication was not restricted. In addition, the references of the articles obtained were checked for suitable papers. Articles were included if they detailed a study to explore picture naming in AD patients and healthy controls. For the purpose of the meta-analysis, these were then sorted into those using items taken solely from the Snodgrass and Vanderwart (1980) corpus, and those who incorporated the Snodgrass and Vanderwart (1980) corpus alongside other stimuli, or solely relied on images obtained from other corpora.

Criteria for inclusion were that the study presented naming data (means and standard deviations) from both the living and nonliving domains, for AD patients and/or healthy participants. Therefore, although we originally found 34 studies of category-specificity in AD that matched the search criteria, only 19 studies were suitable for the analysis (see appendix I, page for details of studies excluded). Studies were excluded if they did not present the data necessary for calculation of effect sizes, if they did not compare patients to controls or did not provide the ‘n’ value for controls, or if they used a semantic task other than picture naming. Nevertheless, several contained more than one study (or analysis) using data sets from several patient groups (e.g. Adlington, Laws, & Gale, 2009; Gonnerman et al., 1997; Laws et al., 2005; Silveri et al., 1991). In these instances, the data from each study was included in the analysis. There were also two studies (Moreno-Martínez et al., 2008; Tippett et al., 2007), which provided more than one data set using the same participants. In this instance, the arithmetic mean effect size was calculated using the individual effect sizes from each data set. The details of all studies included in the meta-analysis are presented in table 9.1. The means and standard deviations from each study were used to calculate the effect size Cohen’s *d*, the difference between the means for the patient and control groups divided by their pooled standard deviation. In addition,

when the SV stimuli were employed (4/13 compared to 10/11 respectively). Therefore, it was felt that this was a suitable criteria for division of the studies, and provided a representative view of the literature.

Hedges'd correction was used to account for the tendency of studies with small samples, to overestimate the population effect size (Hedges & Olkin, 1985).

MetaWin 2.1 (Rosenberg, Adams, & Gurevitch, 2000) was used to conduct the meta-analysis, using a random-effects model in all analyses, which assumes random variation in the effect of interest between the studies. For all analyses, the homogeneity statistic (Q_{wi}; Hedges & Olkin, 1985) was calculated to ascertain whether the studies share a common population effect size (such that a significant Q_{wi} value indicates heterogeneity of the individual study effect sizes). In addition, to test the significance of the mean effect, bias-corrected confidence intervals were obtained using bootstrapping with 999 replications, an approach which is useful in the analysis of this type of data, as it does not require that data be normally distributed. This was again conducted using MetaWin 2.1 (Rosenberg et al., 2000). Effect sizes that differ significantly from zero, when the confidence interval does not include zero, are deemed significant. Finally, the Q_B statistic was used in categorical analyses to test whether groups of studies differed significantly in their mean effect sizes.

Table 9.1 Background information for all studies included in the meta-analysis

Study	Living mean Patient/ control	Nonliving mean Patient/ control	Age (yrs)	Education (yrs)	MMSE	Stimuli n	Number of matched Variables
			SV Studies				
Chan et al., 2001	91/99	90/99	75.0	16	-	20	1
Gale et al., 2009	71.6/95	81.3/96	83.3	-	22.1	100	3
Garrard et al., 2001	75/90.56	80/93.33	68	11.6	19.9	36	2
Garrard et al., 1998	75/93	79/97	68	11.6	19.9	48	2
Hodges et al., 1992	71.25/97.08	76.25/96.67	72.3	13.7	20.7	48	1
Laws et al., 2005, (expt.1)	60.11/94.66	55/90.35	77.9	-	13.7	40	3
Laws et al., 2005, (expt.2a)	65.62/95.91	66.59/95.44	71.5	-	18	64	3
Perri et al., 2003	73/93	77.67/95	70.7	9.2	21.1	60	6
Silveri et al., 2002	56.9/85.4	60.2/88.3	70.2	9.2	17.9	80	5
Tippett et al., 2007	67.98/94.72	66.84/95.93	75.18	12.24	18.6	34.4	5
Zannino et al. , 2002	74.33/93.33	79.33/94.33	68.6	9.1	20.6	60	7

Non-SV studies							
Adlington et al., 2009 (colour)	29.03/64.26	38.13/70.44	81.6	12.3	21.3	105	5
Adlington et al., 2009 (greyscale)	27.08/52.4	37.72/65.05	78	10.8	21.4	105	5
Adlington et al., 2009 (line-drawn)	19.58/36.01	39.53/55.89	78.93	10.7	23.7	105	5
Cuetos et al., 2005	91/99	90/99	75	16	-	80	5
Fung et al., 2001	31/81	41/81	80.6	11.2	22.5	48	2
Gainotti et al., 1996	59.5/89.5	85.5/99.5	68.3	6.3	12.8	40	3
Gonnerman et al., 1997 (expt. 1)	83.3/99.4	85.2/99.4	75.5	13.7	19	36	1
Gonnerman et al., 1997 (expt. 2)	75/97	83.1/97.2	76.3	13.7	18	72	1
Moreno-Martínez et al., 2007a	66/89	81/96	73.8	7.9	20.5	112	4
Moreno-Martínez et al., 2007b	66/89	81/97	73.8	7.9	20.5	112	4
Moreno-Martínez et al., 2008	61/86.69	75.5/95.19	72.8	8.1	21.2	112	4
Silveri et al., 1991 (mild AD)	72.5/99	95/98.5	-	-	-	40	0
Silveri et al., 1991 (mod AD)	39.5/99	65/98.5	-	-	-	40	0

9.3 RESULTS

9.3.1 Do the effect sizes obtained for patients and controls differ across image sets?

Analyses were carried out across both the SV studies and the non-SV studies, to explore whether effect sizes differed as a function of image set. Initially, for both the SV and non-SV studies, effect sizes (Cohen’s d) were calculated for the difference between living and nonliving within participant group, thus an effect size for controls and AD patients. In addition, 95% confidence intervals were derived from 999 bootstrap samples. For the SV studies (see table 9.2), this revealed a small effect size for controls and for AD patients. The effect sizes obtained for patients and controls did not differ significantly. For the non-SV studies, somewhat larger effect sizes were found for controls and for AD patients. As before, the effect sizes obtained for patients and controls for the non-SV studies were not found to differ significantly.

Table 9.2 Effect sizes for patients and controls for the SV and non-SV studies comparing performance across living and nonliving things

	SV	***Non-SV***
Patients	d=0.16 [95%CI 0.06 to 0.26]	d=0.82 [95%CI 0.49 to 1.19]
	Q_{wi} = 5.67; df =10; p=0.84	Q_{wi} = 15.28; df =12; p=0.23
Controls	d=0.19 [95%CI 0.04 to 0.31]	d=0.45 [95%CI 0.17 to 0.72]
	Q_{wi} = 7.59; df =10; p=0.67	Q_{wi} = 14.25; df=12; p=0.28
Patients v controls	$Q_{1,20}$=0.08; p=0.78	$Q_{1,24}$=2.27; p=0.13
	Q_b=13.35; df = 21; p=0.89	Q_b=32.08; df = 25; p=0.16

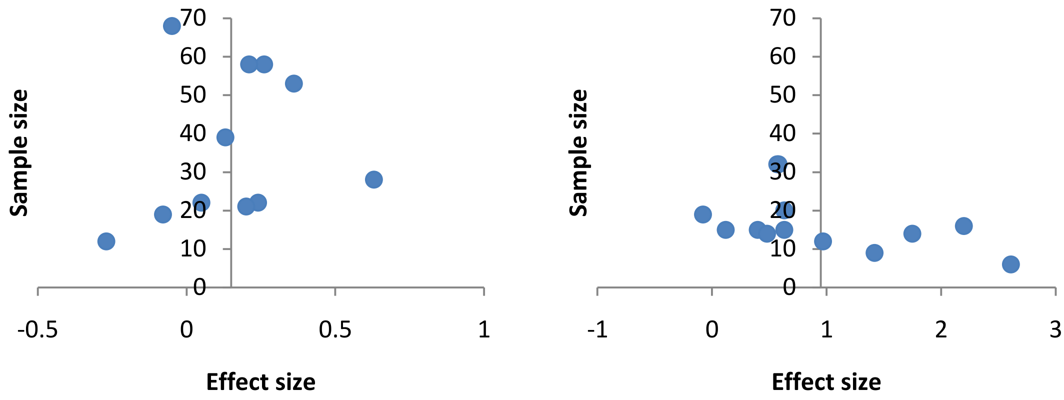
Note. All analyses had homogenous samples.

Though the effect sizes obtained for the non-SV studies were larger than those obtained for the SV studies, this did not reach significance for controls ($Q_{1,22}$=2.56; p=0.11; Q_b=27.38; df = 23; p=0.24). By contrast, the effect size obtained for patients using the non-SV studies was significantly larger than that for SV-studies ($Q_{1,22}$=12.38; p<0.001), with heterogeneity between the studies included (Q_b=40.48; df = 23; p=0.01).

These findings suggest that as the effect sizes for patients and controls do not differ, it is likely that the deficits seen in patients are simply an exaggeration of the normal trend, and as figures 9.1 and 9.2 suggest, both patients and controls appear to perform worse with living things, though there are several exceptions (Chan et al., 2001; Cuetos et al., 2005; Hodges et al., 1992; Laws et al., 2005 expt 1&2a; Silveri et al., 1991; Tippett et al., 2007)[20].

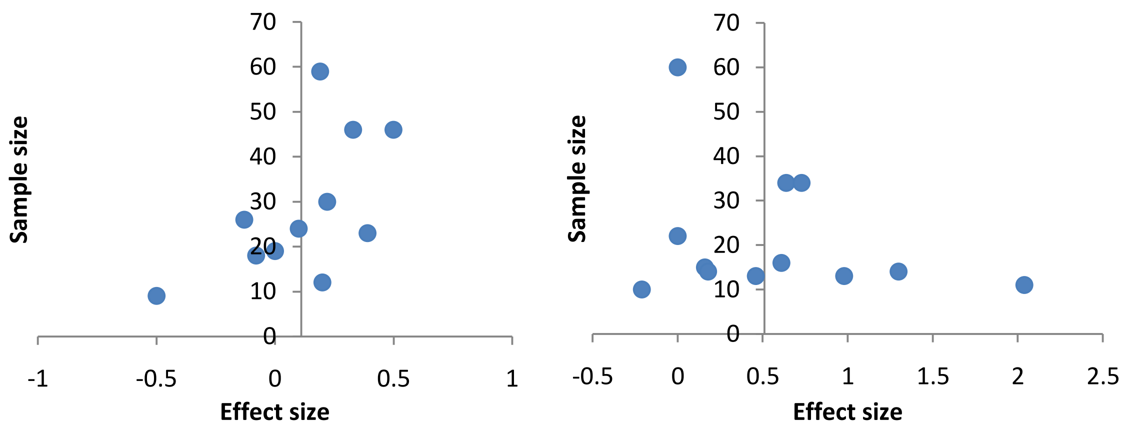
[20] All patient and control effect sizes (living versus nonliving) are reported in Appendix J

Figure 9.1 Effect sizes showing the difference between living and nonliving things for patients across the SV (left) and non-SV (right) studies included in the meta-analysis



Note. Negative figures reveal better performance with living things. Y-axis crosses X-axis at mean effect size.

Figure 9.2 Effect sizes showing the difference between living and nonliving things for controls across the SV (left) and non-SV (right) studies included in the meta-analysis



Note. Negative figures reveal better performance with living things. Y-axis crosses X-axis at mean effect size.

9.3.2 Do the effect sizes for living and nonliving things differ across image sets?

Effect sizes were also calculated for patients versus controls in the recognition of living and nonliving things (see table 9.3). For the SV studies, this revealed a large mean effect for living things, with the Q_{wi} statistic revealing some heterogeneity, and a large effect size for nonliving things. Rosenthal's (Rosenthal, 1979) fail safe calculations (with a probability of p=0.05) were 161.9 and 452 for living and nonliving thing effect sizes respectively. The effect sizes obtained for living and nonliving things were not found to differ significantly, though there was some heterogeneity between studies. For the non-SV studies, again, large effect sizes were obtained for living and nonliving things. As before, Rosenthal's fail safe calculations (with a probability of 0.05) were calculated. These were 237.3 and 324.1 for living and nonliving things respectively. As for the SV studies, the effect sizes obtained for living and nonliving things did not differ significantly.

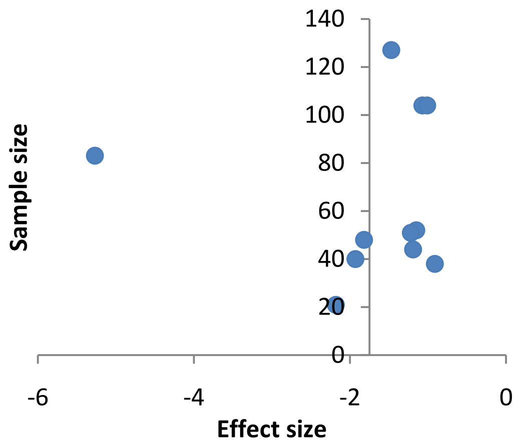
Table 9.3 Effect sizes for living and nonliving for the SV and non-SV studies comparing performance of patients to that of controls.

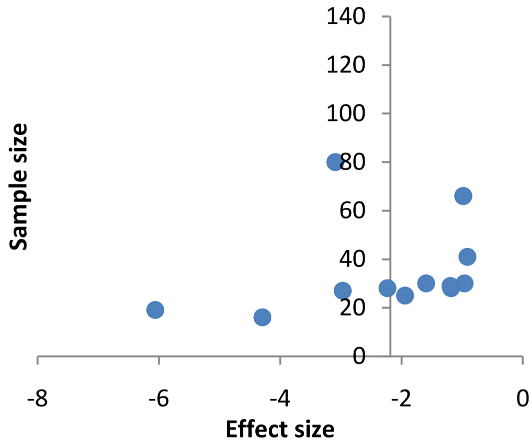
	SV	***Non-SV***
Living things	d=-1.68	d=-1.91
	[95%CI -2.54 to -1.21]	[95%CI -2.62 to -1.34]
Nonliving things	d=-1.26	d=-1.53
	[95%CI -1.47 to -1.06]	[95%CI -1.92 to -1.20]
Living v Nonliving	$Q_{1,20}$=1.52; p=0.22	$Q_{1,24}$=0.82; p=0.37

Note. All analyses had homogeneous samples with the exception of SV living things (Q_{wi} = 18.37; df =10; p=0.05), and SV living versus nonliving analysis (Q_{wi}=34.29; df = 21; p=0.03).

The effect sizes obtained for the SV and non-SV studies were not found to differ significantly for living things ($Q_{1,22}$=0.33; p=0.57; Q_{wi}=38.63; df = 23; p=0.02), or nonliving things ($Q_{1,22}$=1.41; p=0.24; Q_{wi}=24.99; df = 23; p=0.35). These findings therefore suggest that using both the SV and non-SV image sets, neurologically impaired patients show deficits in the recognition of both living and nonliving things relative to controls. Moreover, given that the effect sizes obtained for living and nonliving things were not found to differ significantly, this suggests that patients are equally likely to display a deficit for nonliving things, as they are a deficit for living things, when performance is referenced to controls[21].

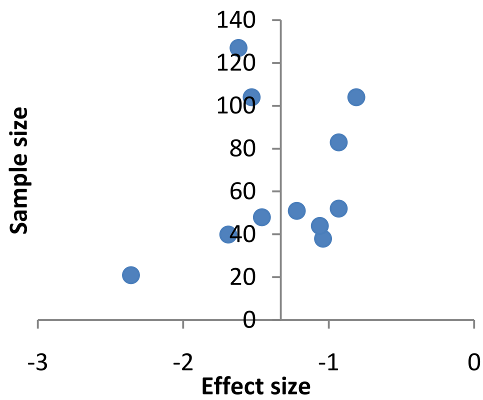
Figure 9.3 Effect sizes for living things for the SV (left) and non-SV (right) studies included in the meta-analysis

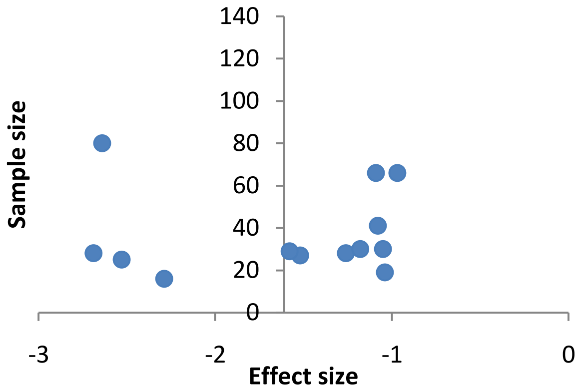




Note. Negative figures show controls are outperforming AD patients. Y-axis crosses X-axis at mean effect size.

Figure 9.4 Effect sizes for nonliving things for the SV (left) and non-SV (right) studies included in the meta-analysis





Note. Negative figures show controls are outperforming AD patients. Y-axis crosses X-axis at mean effect size.

[21] All effect sizes for living and nonliving things (patients versus controls) are reported in Appendix K

9.3.3. Summary of Findings

In summary, in regard to the analysis of patient and control effect sizes, both groups were found to perform worse with living things though the effect sizes obtained for patients and controls were not found to differ significantly, suggesting that patient performance may differ quantitatively, but not qualitatively from that of controls. This is supported by comparison with the effect sizes obtained for living and nonliving things, which show that when referenced to controls, the effect sizes are comparable across domain. Thus, AD patients are equally impaired with living and nonliving things. Concerning the comparison across stimulus set, though the findings obtained with the SV corpus are comparable to those obtained from non-SV studies, the effect sizes obtained for living and nonliving things, and for patients and controls were consistently larger for the non-SV studies, though only significantly so for the patient analysis. Taken in conjunction with the funnel plots, this finding may be the result of greater variance in non-SV studies compared to SV studies, owing to the fact that performance is well below ceiling.

9.4 DISCUSSION

The aim of this study was to explore whether ceiling effects in controls may influence the emergence of category specific deficits in AD patients. As controls typically perform at ceiling when naming items from the Snodgrass and Vanderwart (1980) corpus, performance on this was used as a benchmark, against which performance on other stimuli sets could be compared. Meta-analytic techniques were thus employed to explore whether reports of living and nonliving deficits differ between SV and non-SV studies. In short, the main findings were that the effect sizes obtained for living and nonliving things, through both within-group and between-group comparisons, were somewhat larger for the non-SV studies than for the SV studies. However, the pattern of performance across the SV and non-SV studies was consistent in that there were no significant differences in the effect sizes obtained (i) for living and nonliving things via within-group comparison, and (ii) between living and nonliving things when patients’ performance was compared to that of controls.

Turning firstly to the finding that effect sizes were larger for the non-SV studies than for the SV investigations, although effect sizes were consistently larger for non-SV than SV studies, it was only significant for the living-nonliving differences in AD patients. The larger effect sizes obtained with the non-SV studies demonstrates the greater variance in scores, produced when using stimuli on which naming performance is below ceiling. Indeed, a simple vote count reveals that of the studies included, 10/11 SV studies reported control performance to be above 90% on both categories, while only 4/13 non-SV studies reported ceiling level performance in controls, according to the criteria above. This shows however that there are still several studies not using the SV corpus in which control performance is at ceiling, which may be one reason why the difference in the size of the effect sizes obtained failed to reach significance.

Across the SV and non-SV studies, when patients were referenced to controls, although the effect sizes for living things (SV/non-SV; d=-1.68/-1.91) were larger than those for nonliving things (SV/non-SV; d=-1.26/-1.53) there was no significant difference in the effect sizes obtained, suggesting that AD patients show large but comparable deficits for both domains. The extant literature on category-specificity in AD suggests a higher incidence of living thing deficits. Indeed, of the studies included in the meta-analysis, there are 19 reports of a deficit for living things and 8 reports of a deficit for nonliving things, all of which are found to occur in individual patients within a sample, and are accompanied by patients showing the opposite dissociation, thus highlighting the fact that regardless of the stimuli observed, living deficits are far more commonly documented. By comparison, a simple vote count of those having larger effect sizes for living and nonliving things (when patients are compared to controls) reveals totals of 12 to 11 respectively (see Appendix K). One possible explanation for the disparity between the number of studies documenting living/nonliving deficits and the effect sizes obtained may be that certain studies report both living and nonliving deficits within the same group of patients. Typically when this occurs, the effect size for nonliving things is larger than that for living things, though this is not always the case, and there are several instances where a group living thing deficit is reported but the effect size is larger for nonliving things.

Another potential factor that might account for some of the discrepancy between findings is the way in which studies analyse the data. Typically, studies report category effects on the basis of general comparisons (i.e. group x category analyses) rather than testing in a way that would reveal whether or not there are significant differences between patients and controls on both categories (e.g. Garrard et al., 1998; Gonnerman et al., 1997; Perri et al., 2003; Siveri et al., 1991; Zannino et al., 2002). Thus, if an analysis reveals that patients perform worse than controls overall, and that there is a significant effect of category, with patients showing worse performance with living things, researchers will typically report a deficit for living things. Nevertheless, it remains possible that while patients perform worse with living things than controls, this difference may not reach significance, whereas a difference may be found for nonliving things. In this way researchers, may erroneously report a deficit for living things. Importantly, ceiling effects may distort findings in a similar way (Fung et al., 2001; Laws, 2005; Laws, et al., 2005), thus it is possible that the ceiling effects noted in the majority of SV studies, and also some non-SV studies, may have comparable effects, and again to some extent, account for the disparity between the effect sizes obtained, and what is reported.

According to Laws et al. (Laws, Adlington, Gale, Moreno-Martínez, & Sartori, 2007), one possible explanation as to why the effect sizes obtained may diverge somewhat from the prevailing view is that studies often rely on within-group comparisons. The data obtained in their meta-analysis was comparable to that obtained here, in that the effect sizes obtained for living and nonliving things were equivalent. However they noted that within category analyses revealed a significant living thing decrement in both patients and controls. Likewise, for both the SV and non-SV studies included in the current analysis, a significant disadvantage for living things is apparent in both patients (SV: d=0.16 [95%CI 0.06-0.26]; non-SV: d=0.82 [95%CI 0.49 to 1.19]), and controls (SV: d=0.19 [95%CI 0.04-0.31]; non-SV: d=0.45 [95%CI 0.17 to 0.72]). Thus when AD patients' performance is analysed on the basis of absolute differences alone, a living deficit emerges.

The notion that analysis of patients in reference to controls may impact upon the likelihood of a category specific deficit for living things emerging is consistent with findings reported recently by Gale, Irvine, Laws, and Ferrissey (2009). Using hierarchical regression techniques, they found that the performance of healthy matched controls accounted for 29% of the variance in the naming of AD patients. By comparison, category only accounted for 3%. In a similar vein, Moreno-Martínez and Laws (2008) demonstrated that control naming accuracy was found to account for 64% of the variance in the naming performance of AD participants. Moreover, controls were found to name significantly more nonliving than living things. These results were taken as evidence that the category specific deficit for living things typically reported in AD may simply be an exaggeration of that which occurs normally in healthy elderly controls. Taken in conjunction with the current findings, it is apparent therefore, that failing to compare patient performance to that of controls may greatly influence the likelihood of a category specific deficit emerging.

In summary, the findings of this chapter support those of chapter 8, and recent studies of category specific deficits in AD that show firstly, that the use of within-group comparisons may increase the likelihood of a significant category deficit emerging (Laws et al., 2007; Laws, 2005; Laws et al., 2005), and secondly, that the category effects observed are simply an exaggeration of the normal trend (Gale et al., 2009; Moreno-Martínez & Laws, 2007, 2008). In addition, the meta-analysis demonstrates that although the pattern of performance was consistent across the SV and non-SV studies, the use of the non-SV images produced greater variance in the naming data obtained, thus making the data more amenable for analysis with parametric tests, and increasing the likelihood that category dissociations in control performance may be detected.

Chapter 10: Conclusion

10.1 INTRODUCTION

The previous experimental chapters have examined various aspects of picture naming in Alzheimer's dementia (AD) patients and healthy controls, with the goal of establishing whether category specific deficits do emerge, and the extent to which this may reflect certain methodological factors. Specifically, this thesis has explored the extent to which image format influences object recognition in AD patients and controls, and the extent to which format affects performance across categories. This was motivated by mounting evidence suggesting that the presence of surface detail may be advantageous in object recognition (Brodie, Wallace & Sharrat, 1991, experiment 3; Davidoff & Ostergaard, 1988; Humphrey et al., 1994; Laws & Hunter, 2006; Price & Humphreys, 1989; Rossion & Pourtois, 2004; Tanaka & Presnell, 1999; Williams & Tanaka, 2000; Wurm et al., 1993; Zannino, Perri, Caltagirone, & Carlesimo, 2007) and, perhaps more importantly, that the extent to which surface information aids object recognition depends upon the characteristics of the item. In particular, research has shown that items which are highly colour diagnostic, or for which shape is not sufficient for identification (i.e. objects with high structural similarity), are more readily named when presented in colour than as line drawings (Price & Humpreys, 1989; Tanaka & Presnell, 1999; Wurm et al., 1993). Importantly, these characteristics are typically associated with items from the living domain (Humphrey et al., 1994; McCrae, 1992). Thus, this would suggest that the presence of surface information may be more important for the recognition of living things. Therefore, the predominant use of line drawings in category specific research might automatically create a disadvantage for living things, and might in part, account for the prevalence of living thing deficits reported in the literature.

In conjunction with the effects of format, a second aim was to investigate the extent to which participant factors, particularly control performance, might influence the emergence of category specific deficits in AD. Recent studies have demonstrated that when interpreting AD patient performance, a reliance on within-group comparisons, or use of control data in which performance is at ceiling, may distort both the degree and type of category specific impairment documented (Fung, Chertkow, Murtha, Whatmough, Peloquin et al., 2001; Laws, Gale, Leeson & Crawford, 2005). Nonetheless, the majority of studies in the area employ controls who are performing at or near ceiling. One explanation for this is that most studies employ stimuli such as the Snodgrass and Vanderwart (1980) corpus, which comprises line drawings of familiar, everyday items that are relatively easy for controls to name. As such, healthy controls are often able to obtain a near perfect score. Thus, not only has this led to problems with interpretation of AD patient performance, but conflicting findings exist as to the normal category specific profile. Indeed, in an attempt to avoid ceiling performance in controls, several studies have introduced time constraints (Brousseau & Buchanan, 2004; Filliter, McMullen & Westwood, 2005; Gerlach, 2001; Låg, 2005; Laws, 2000; Laws & Neve, 1999; Lloyd-Jones & Luckhurst, 2002). Such studies have typically documented a living advantage in healthy participants, though this is at odds with findings demonstrating a nonliving advantage when low frequency items are used or bootstrapping techniques are employed to counteract ceiling level performance (Coppens & Frisinger, 2005; Moreno-Martínez & Laws, 2007, 2008). This inconsistency among findings has been accounted for as a result of increased task demands which, in line with the visual crowding hypothesis (Gaffan & Heywood, 1993; Gale, Done, & Frank, 2001; Humphreys et al., 1988, 1995) and pre-semantic account of category effects (PACE: Gerlach, Law, & Paulson, 2004, 2006), would inadvertently create a disadvantage for nonliving things. Thus, it is evident that to better understand the normal category profile; further research is needed that employs images on which naming performance is below ceiling.

10.2 THE HATFIELD IMAGE TEST (HIT)

To address the issue of ceiling effects and to provide a corpus of images that would allow researchers to investigate the influence of format on object recognition, the initial concern of the thesis was the development of a novel corpus of images that incorporated low, medium, and high frequency items to prevent performance reaching ceiling. Chapters 3 and 4 detail the development of the Hatfield Image Test (HIT), a corpus of 147 items representing 8 nonliving and 7 living thing subcategories, with all items depicted in colour, greyscale, and line-drawn formats, and details such as size, shape, and orientation maintained across format. Within each subcategory there were ranges of low to high frequency items to allow the production of matched subsets of items that vary in naming difficulty but encompass items from a number of subcategories. Overall, normative naming across the corpus approximated a normal distribution, thus avoiding the problem of ceiling level performance and making the HIT amenable for use with parametric analyses.

To supplement the development of the corpus, normative data was collected for a number of nuisance variables found to influence object naming, namely; age of acquisition, familiarity to name and to image, name agreement (as measured by the H-statistic and percentage name agreement), visual complexity, and word frequency. Given that this set was designed to allow exploration of the effects of colour on object naming, ratings of colour diagnosticity were also obtained. Regression analyses were conducted in chapters 4 and 5 to assess the extent to which these nuisance variables predicted normative naming across the whole corpus, and across a matched subset of 105 items respectively. In both analyses, familiarity and name agreement emerged as significant predictors, which is consistent with previous research (Albanese, Capitani, Barbarotto, & Laiacona, 2000; Brown & Watson, 1987; Funnell & Sheridan, 1992; Gernsbacher, 1984; Gilhooly & Gilhooly, 1979; Gilhooly & Logie, 1981; Hodgson & Ellis, 1998; Lachman, Schaffer, & Hennrikus, 1974; Mitchell, 1989; Paivio, Clark, Digdon, & Bons, 1989; Vitkovitch & Tyrell, 1995).

Conversely, age of acquisition, which has previously emerged as a powerful predictor of naming (Brown & Watson, 1987; Coltheart, Laxon, & Keating, 1988; Frederiksen & Kroll, 1976; Gilhooly & Logie, 1982; Humphreys, Riddoch, & Quinlan, 1988; Monsell et al., 1989; Oldfield & Wingfield, 1965) did not predict naming on the HIT. It was argued that this might be an artefact of the images included in this corpus, and the measure of age of acquisition employed. Indeed, as a proportion of the items featured in the HIT are low frequency, low familiarity items, it is likely that they were acquired later in life. However, the scale used to measure age of acquisition (Taken from Carroll & White, 1973) only records up to 13+years of age. Therefore, it is likely that there would be a large degree of variance in the items rated as acquired late in life, thus reducing the sensitivity of the scale. Though this may arguably have implications regarding the usefulness of this measure when producing sets of items matched for age of acquisition across the living and nonliving domains, given that there is variance in the frequency of items within each subcategory, and that age of acquisition varied significantly across subcategory, this is unlikely to be problematic.

10.3. THE INFLUENCE OF FORMAT ON OBJECT RECOGNITION

As noted above, the main aim of this thesis was to explore the extent to which format influenced object recognition in both AD patients and healthy controls, and whether or not the effects of image format interacted with category. The effects of format were found to vary greatly dependent upon a number of factors, including group (i.e. AD patient or control). For this reason, the influence of format on the performance of controls and AD patients will be discussed separately.

10.3.1 The influence of format upon picture naming in controls

A main effect of format was noted in chapters 5 and 6 when controls viewed a matched (i.e. more difficult) subset of items from the HIT corpus, though it failed to emerge in chapters 4 and 8, when controls were shown the entire corpus, that includes a greater number of high familiarity items. Where an effect of format occurred, performance improved linearly with the addition of surface detail. Therefore, it was tentatively suggested that where there is no effect of format, it might be that naming difficulty was interacting with the effects of image format. In these instances, controls viewed the entire corpus of 147 images, rather than the subset of 105 images used in chapters 5 and 6. This smaller subset had overall, a lower rating of word frequency and familiarity than the entire corpus, and therefore, had comparatively higher naming difficulty. Thus, it was hypothesised that this inconsistency across chapters may occur because colour is more beneficial in the recognition of low frequency, low familiarity items, where participants may know the item but have more difficulty naming the item. Under these conditions, the additional visual information provided by the presence of surface detail may aid the selection of semantic memory representations. Though only a provisional hypothesis, this receives support from findings in chapters 5 and 6, in which the effects of format were compared across easy and difficult subsets of the HIT. Turning to chapter 6 first, this revealed that the effect of format found for the 105 items, was only replicated using the more difficult subset. By contrast, naming of the items in the easy subset did not benefit from the presence of surface detail, suggesting that when picture naming is easy, image format may not be as influential on object naming. However, when this analysis was conducted in chapter 5, an effect of format emerged for both the easy and difficult subsets. Nevertheless, as this was a reaction time study, this may be attributed to increased task demands, which would in turn, increase naming difficulty.

Though this is only a tentative suggestion, and one that requires further research, the idea that colour may be more important for the recognition of low frequency, low familiarity items may have implications for category specific research. Firstly, given that living things are thought to have lower word frequency and be less familiar than nonliving things (Barbarotto, Capitani, & Laiacona, 2001; Gale & Laws, 2006), this may also account for the finding that the recognition of living things benefits more from the presence of colour than that of nonliving things. Thus, the use of line drawings may create a disadvantage for living things

Where an effect of format emerged, participants naming performance was found to improve linearly with the addition of surface detail; in chapter 5, where only colour and line-drawn versions of the items were used, performance was better with the colour items, whilst in chapter 6, controls named fewer items when they were presented as line drawings, than when they were presented in greyscale, and fewer greyscale than colour items. In addition, regression analyses conducted in chapter 6 revealed image format to be a significant predictor of naming accuracy across both living and nonliving things. These findings accord with previous research showing that surface detail improves object recognition (Brodie, Wallace & Sharrat, 1991, experiment 3; Davidoff & Ostergaard, 1988; Humphrey et al., 1994; Laws & Hunter, 2006; Price & Humphreys, 1989; Rossion & Pourtois, 2004; Tanaka & Presnell, 1999; Williams & Tanaka, 2000; Wurm et al., 1993; Zannino, Perri, Caltagirone, & Carlesimo, 2007).

In addition to the main effect of format observed in chapters 5 and 6, both also revealed a significant format by category interaction. Findings were consistent with previous research suggesting that the high structural similarity and colour diagnosticity of living things would mean that colour would be more advantageous in the recognition of items from this domain. Moreover, the findings also showed that the extent to which the influence of colour differs across category might in fact influence the emergence of a category specific deficit. Indeed, in chapter 5, a significant advantage for nonliving things emerged in controls for line drawings, but not the colour versions of the HIT corpus. Correspondingly, in chapter 6 a main effect of category was shown by controls for the line-drawn and greyscale images, but not for the colour versions. This finding therefore, has important implications for category specific research in that it shows that the use of line drawings may exaggerate the disadvantage for living things observed in controls, leading to type I errors.

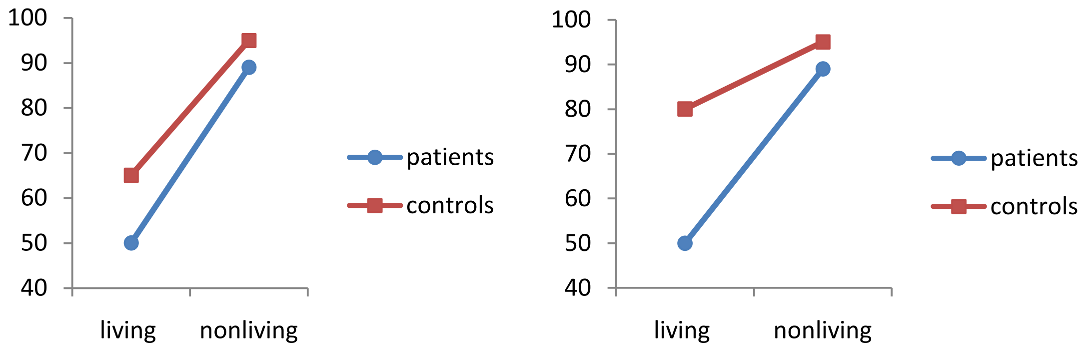
10.3.2 The influence of format upon picture naming in patients

As noted above, the impact of image format for AD patient and controls differed markedly. In contrast to controls, AD patients showed no main effect of format in any of the investigations. Nevertheless, in chapter 8, post hoc analyses did show that AD patient performance improved with surface detail, though this only reached significance for living things, with performance improving linearly. For nonliving things, a significant difference was only observed when viewing the Snodgrass and Vanderwart (1980) images, and only between colour and greyscale items. Thus, rather than suggesting that format has no effect on picture naming in AD, the findings of these studies suggest that the pattern of results obtained reflects that obtained with controls, though the effects of format are not as pronounced. This is evidenced further as both chapters 6 and 8 reported format by category interactions, with colour emerging as more important for the recognition of living things.

That unlike controls, AD patients do not benefit from the addition of surface detail is consistent with the ideas of Laws, Adlington, Gale, Moreno-Martínez, and Sartori (2007), who argue that visual cortical deficits in AD, caused by the development of senile plaques, neurofibrillary tangles, and astrocytic gliosis in the striate cortex (Beech & McGeer, 1988), may impair patient ability to process colour. Chapter 6 corroborates this idea in that not only did AD patients exhibit significantly poorer performance than controls on tests of low-level visual functioning, but also performance on low-level visual tasks significantly predicted naming. More importantly however, the presence of low-level visual impairments predicted the naming of living things. As noted above, image format also emerged as a significant predictor of the variance in AD patients' naming ability with items from this domain. Thus, it appears that although surface detail is more important for the recognition of living things than nonliving things, AD patients are unable to utilise this information to aid object recognition because of low-level visual impairments. This therefore, may account for the finding of an interaction between format and category.

Taken together, the finding that surface detail significantly predicts the naming of living but not nonliving things in AD, and that low-level visual cortical impairments observed in AD have a greater impact on the naming of living things, these findings have important implications for category specific research. For instance, when comparing patients to controls, it highlights the necessity to take into consideration the format of image presentation. As figure 10.1 illustrates, compared to the use of line drawings, which would be equally detrimental to both AD patients and controls naming of living things, the use of colour images might improve control naming of living things, but not that of patients, creating a an apparent category effect for living things.

Figure 10.1 Example of the potential effects of comparing AD patients to controls using line-drawn (left) and colour (right) stimuli.



10.4 PARTICIPANT AND CONTROL GROUP FACTORS

The second aim of the thesis was to explore the extent to which participant factors influence the emergence of category specific effects. Initially, rather than participant effects, the main concern was control group factors. In particular, the initial part of the thesis was concerned with identifying the 'normal' category specific trend, while the later chapters looked to demonstrate how the absence of control data might influence category specific naming, and whether the use of controls performing below ceiling influenced the incidence of category specific deficits in AD. In addition, however, chapter 6 showed that certain participant characteristics might also influence category-specificity in AD; as such, these factors are discussed briefly, before attending to the issue of control group factors.

10.4.1 Participant Factors

Though exploration of the influence of participant factors on category specific naming performance was not a major concern of this thesis, nonetheless some findings warrant further consideration. In particular, the regression analyses conducted in chapter 6 revealed that whilst the naming of living things in AD was largely dependent upon image factors (specifically image format and low-level visual impairment), the naming of nonliving things was predicted by the participant variables of age, sex, and MMSE score, such that better naming of nonliving things was exhibited by younger males, with lower MMSE scores. Though previous research has demonstrated that age (e.g. Barresi, Nicholas, Connor, Obler, & Albert, 2000; Farmer, 1990; Ivnik, Malec, Smith, Tangalos, & Peterson, 1996; Kavé et al., 2009; Worrall, Yiu, Hickson, & Barnett, 1995), disease severity as indicated by MMSE score (e.g. Garrard et al., 1998; Gonnerman, Andersen, Devlin, & Seidenberg, 1997; Whatmough et al., 2003), and sex (Laiacona, Barbarotto & Capitani, 1998), may all influence object naming, to the authors knowledge and with the exception of sex, this is the first study to show that the influence of these variables may differ across category. This finding arguably implies therefore, that (i) a deficit for nonliving things may be more likely to occur in older female patients with lower MMSE scores, and (ii) taken in conjunction with the knowledge that living thing deficits are more dependent upon visual factors, this suggests the naming of living and nonliving things is dependent upon quite different underlying processes.

10.4.2 The normal naming profile, ceiling effects, and within-group comparisons

As discussed in detail in chapter 1, knowledge of the normal naming profile is essential for proper interpretation of AD patient performance. Despite this, only recently has research been conducted that explores the 'normal' category specific trend. Moreover, that which has been conducted has revealed evidence of both a living (Brousseau & Buchanan, 2004; Filliter, McMullen & Westwood, 2005; Gerlach, 2001; Låg, 2005; Laws, 2000; Laws & Neve, 1999; Lloyd-Jones & Luckhurst, 2002) and nonliving (Coppens & Frisinger, 2005; Gaffan & Heywood, 1993; Humphreys, Riddoch, & Quinlan, 1988; Lloyd-Jones & Humphreys, 1997) advantage in healthy controls. This inconsistency has been attributed to the use of stimuli that were not matched across category for nuisance variables (Laws & Neve, 1999), and also to confounds introduced through the use of time constraints (Gerlach, 2001; Låg, 2005; Laws & Neve, 1999). Concerning the latter, time constraints were introduced to prevent control performance reaching ceiling, however it has been shown that doing so might result in an advantage for living things (Gerlach, 2001; Låg, 2005; Laws & Neve, 1999). Thus the initial chapters of this thesis explore the normative trend using the HIT items, on which naming is below ceiling.

Using the HIT, throughout the thesis, controls consistently showed an advantage for nonliving things. Whether this was significant depended upon the format of the images presented, with colour images typically preventing the emergence of a significant category effect. Interestingly, chapter 8 demonstrated that ceiling level performance might mask category specific effects. Indeed, while controls displayed a nonliving advantage across all formats of the HIT, a significant nonliving advantage only emerged for the line-drawn versions of the Snodgrass and Vanderwart (1980) corpus, for which performance was off ceiling.

That controls consistently exhibited a nonliving advantage indicates that the pattern of performance exhibited by AD patients reflects the norm. This claim receives support from the meta-analysis reported in chapter 9, and from experimental data in chapters 7 and 8. Concerning the meta-analysis firstly; this showed that both controls and patients named fewer living than nonliving things. More importantly, it noted that although patients named fewer living things when performance was analysed based on absolute differences, when patient performance was referenced to controls, the effect sizes obtained for living and nonliving things were comparable. Therefore, this conflicts with the prevailing view that living things deficits more commonly occur. Rather in accordance with the findings of Laws et al., (2007), it suggests that the high incidence of living thing cases reported in the literature may be a product of within-group comparisons.

Experimental data obtained in chapters 7 and 8 supports this notion. Taken together, the findings of these studies show that both over time and at a single testing session, AD patients were found to show a deficit for living things based on absolute differences, but when compared to controls, a significant category effect failed to emerge, or was only found to emerge when patients were presented with line-drawn stimuli. Thus, these findings demonstrate that the category effect observed in AD patients differs quantitatively, but not qualitatively from that of controls.

The claim that category specific deficits for living things are simply an exaggeration of the normal naming profile has important theoretical implications. As the majority of theories were designed to account for the pattern of performance observed in neurologically impaired patients, no explicit predictions were made as to the normal naming profile, and little attempt has been made to link the pattern of performance observed in AD patients to that of healthy controls. For example, the sensory-functional account (Warrington & McCarthy, 1983), cannot explain a normal advantage for nonliving things. The correlated structures accounts (Gonnerman, Andersen, Devlin, Kempler, & Seidenberg, 1997; Moss, Tyler, Durrant-Peatfield, & Bunn, 1998), developed specifically to address category specific naming in AD also fail to predict what might occur in controls. Similarly, though the artefactual account (Funnell & Sheridan, 1992; Stewart, Parkin, & Hunkin, 1992) might predict a nonliving advantage when stimuli are not matched across category for important nuisance variables, this would not be expected when stimuli are matched. Furthermore, though again, the domain-specific hypothesis (Caramazza & Mahon, 2003; Caramazza & Shelton, 1998; Mahon & Caramazza, 2003) makes no explicit predictions, the evolution of specific neural mechanisms for the processing of living things, would arguably have occurred to make processing of these items more efficient. Thus, based on this account, a normal advantage for living things might be expected.

One theory that can however account for the normal advantage for nonliving things is the pre-semantic account of category-effects (PACE: Gerlach, Law, & Paulson, 2004, 2006). This posits that a category effect may occur pre-semantically owing to the effects of structural similarity at two key points in the object recognition process, shape configuration and selection. Based on the assumption that living things are more structurally similar, it is argued that at the shape configuration stage, an advantage will occur for items from this domain as structurally similar items are more easily recognised on the basis of global features that are processed more readily. However, a nonliving advantage will occur overall, as the high structural similarity of living things considerably slows down the matching of the temporary representation to that of stored representations owing to the fact that this increases the number of possible items competing for selection. Thus, this would account for the normal advantage for nonliving things under optimal viewing conditions. Though the PACE model provides a plausible account of how category specific effects may occur in controls (and in AD patients, see Gerlach, 2009), it nevertheless is based on the idea that living things are more structurally similar than nonliving things. However, research suggests that this depends largely upon what measure of structural similarity is employed (Humphreys et al., 1988; Laws & Gale, 2002; Tranel et al., 1997). Nonetheless, it remains at present, the only account of category-specificity that might explain the normal advantage for nonliving things, and it is therefore interesting to note, that this suggests that category specific effects emerge at a pre-semantic stage of object recognition.

10.5 CONCLUSION

In summary, the findings presented in this thesis confirm and extend previous findings relating to the role of control group factors and format in category specific research. Concerning the former, the findings of this thesis show that both AD patients and controls show an advantage in the recognition of nonliving things, and moreover, that when compared to controls performing below ceiling, it is apparent that the pattern of performance observed in AD patients is just an exaggeration of the norm. This therefore highlights the need for researchers to reconsider the factors underlying the emergence of category specific disorders. Indeed, only the PACE account offers a model that could explain category specific effects in both neurologically impaired and intact individuals and does so in reference to pre-semantic stages of processing. That the emergence of category specific deficits can be explained as a result of damage to pre-semantic processes also highlights the fact that novel theories of category-specificity will need to consider whether damage to other processes within the object recognition system might in part, account for category specific effects in AD and healthy controls.

The need to consider the role of pre-semantic stages of object recognition in the emergence of category effects is further accentuated through findings denoting an interaction between image format and category. The research presented here provides support for previous studies that show firstly, that surface detail is beneficial to object recognition in healthy controls (Brodie, Wallace & Sharrat, 1991, experiment 3; Davidoff & Ostergaard, 1988; Humphrey et al., 1994; Laws & Hunter, 2006; Price &

Humphreys, 1989; Rossion & Pourtois, 2004; Tanaka & Presnell, 1999; Williams & Tanaka, 2000; Wurm et al., 1993;Zannino, Perri, Caltagirone, & Carlesimo, 2007), and secondly, that the effect of surface detail on object recognition in controls is more pronounced for items from the living domain (Humphrey et al., 1994; McCrae, 1992; Price & Humpreys, 1989; Tanaka & Presnell, 1999; Wurm et al., 1993). However, it also goes further to demonstrate that the fact that living things benefit more from the addition of colour may ultimately interact with category, with the presence of colour leading to improved performance with living things, at least in controls. Indeed, another interesting finding that has emerged from this thesis is that contrary to what might have been predicted, AD patients do not benefit from colour to the same extent as controls. This was found to occur as a result of low-level visual deficits in AD, impairing the processing of colour information. Thus, this may in part account for the high incidence of living thing deficits reported in the category specific literature. Moreover, this again demonstrates how impairments at pre-semantic stages of object recognition may contribute to the emergence of category specific deficits.

The findings relating to image format and control performance have important implications for theories and research relating to category-specificity in AD. However, it is important also to note that it would not have been possible to conduct this research without the development of the HIT corpus. This therefore represents a further contribution of this thesis to category specific research, and moreover, other areas of clinical and experimental research that might benefit from the availability of a large corpus of images that will allow further exploration of the factors mediating object recognition performance in neurologically intact individual.

References

Adlington, R. L., Laws, K. R., & Gale, T. M. (2009). The Hatfield Image Test (HIT): a new picture test and norms for experimental and clinical use. *Journal of Clinical and Experimental Neuropsychology, 31*, 731-753.

Adlington, R. L., Laws, K. R., & Gale, T. M. (2009). The influence of surface detail and colour on picture naming in Alzheimer's disease. *Brain and Cognition,* in press.

Ahmed, S., Arnold, R., Thompson, S. A., Graham, K. S., & Hodges, J. R. (2008). Naming of objects, faces and buildings in mild cognitive impairment. *Cortex, 44,* 746-752.

Alario, F. X., Ferrand, L., Laganaro, M., New, B., Frauenfelder, U. H., & Segui, J. (2004). Predictors of picture naming speed. *Behavior Research Methods, Instruments, & Computers, 36,* 140-155.

Albanese, E. (2007). The "hidden" semantic category dissociation in mild-moderate Alzheimer's disease patients. *Neuropscyhologia, 45,* 639-643.

Albanese, E., Capitani, E., Barbarotto, R., & Laiacona, M., (2000). Semantic category dissociations, familiarity and gender. *Cortex, 36,* 733-746.

AllSearch engines.com homepage, (May, 2000). Available: http://www.allsearchengines.com

Altavista.com homepage, (April 2008). Available: http://www.altavista.com

Ardila, A., Ostrosky-Solis, F., Rosselli, M., & Gómez, C. (2000). Age-related cognitive decline during normal aging: the complex effect of education. *Archives of Clinical Neuropsychology, 15*, 495-513.

Arguin, M., Bub, D., & Dudek, G. (1996). Shape integration for visual object recognition and its implications in category specific visual agnosia. *Visual Cognition, 3,* 221-275.

Arnold, S. E., Hyman, B. T., Flory, J., Damasio, A. R., & Van Hoesen, G. W. (1991). The topographical and neuroanatomical distribution of neurofibrillary tangles and neuritic plaques in the cerebral cortex of patients with Alzheimer's disease. *Cerebral Cortex, 1*, 103-116.

Au, R., Joung, P., Nicholas, M., Obler, L. K., Kass, R., & Albert, M. L. (1995). Naming ability across the adult life span. *Aging and Cognition, 2,* 300–311.

Baayen, R. H., Piepenbrock. R., & Gulikers, L. (1995). *The CELEX lexical database.* Philadelphia: University of Pennsylvania, Linguistic Data Consortium.

Bar, M., Tootell, R. B., Schacter, D. L., Greve, D. N., Fischl, B., Mendola, J. D., et al. (2001). Cortical mechanisms specific to explicit visual object recognition. *Neuron, 29*, 529-535.

Barbarotto, R., Capitani, E., & Laiacona, M. (2001). Living musical instruments and inanimate body parts. Neuropsychologia, *39,* 406-414.

Barbarotto, R., Capitani, E., & Laiacona, M. (1996). Naming deficit in herpes simplex encephalitis. *Acta Neurologica Scandinavica, 93,* 272-280.

Barbarotto, R., Laiacona, M., & Capitani E. (2008). Does sex influence the age of acquisition of common names? A contrast of different semantic categories. *Cortex, 44,* 1161-1170.

Barbarotto, R., Laiacona, M., Macchi, V., & Capitani, E. (2002). Picture reality decision, semantic categories and gender – A new set of pictures, with norms and an experimental study. *Neuropsychologia, 40*, 1637-1653.

Barker, M. & Lawson, J. (1968). Nominal aphasia in dementia. *British Journal of Psychiatry, 114*, 1351-1356.

Barresi, B. A., Nicholas, M., Conner, L. T., Obler, L. K., & Albert, M. L. (2000). Semantic degradation and lexical access in age-related naming failures. *Aging Neuropsychology and Cognition, 7,* 169-178.

Basso, A., Capitani, E., & Laiacona, M. (1988). Progressive language impairment without dementia – a case with isolated category specific semantic defect. *Journal of Neurology Neurosurgery and Psychiatry, 51,* 1201-1207.

Bauer, P. J., & Mandler, J. M. (1989). One thing follows another: Effects of temporal structure on 1- to 2-year olds' recall of events. *Developmental Psychology, 28,* 441-452.

Bayles, K.A., & Tomoeda, C.K. (1983). Confrontation naming impairment in dementia. *Brain & Language, 19,* 98-114.

Bayles, K. A., Tomoeda, C.K., Kaszniak, A. W., & Trosset, M. W. (1991). Alzheimer's disease effects on semantic memory: Loss of structure or impaired processing? *Journal of Cognitive Neuroscience, 3,* 166-182.

Bayles, K. A., Tomoeda, C.K., & Trosset, M.W. (1990). Naming and categorical knowledge in Alzheimer's disease: The process of semantic memory deterioration. *Brain and Language, 39,* 498-510.

Beach TG, & McGeer EG. (1988). Lamina-specific arrangement of astrocytic gliosis and senile plaques in Alzheimer's disease visual cortex. *Brain Research, 463*, 357–61.

Bergevin, A., & Levine, M. D. (1993). Generic object recognition: Building and matching coarse descriptions from line drawings. *IEEE Transactions of Pattern Recognition and Machine Intelligence, 15,* 19-36.

Berndt, R. S., Burton, M. W., Haendiges, A. N., *&* Mitchum, C. C. (2002). Production of nouns and verbs in aphasia: effects of elicitation context. *Aphasiology, 16,* 83-106.

Biederman, I. (1987). Recognition by components: a theory of human image understanding. *Psychological Review, 94,* 115-147.

Biederman, I., & Hilton, H. J. (1987). *Recognition of objects that require texture specification.* Unpublished Manuscript, SUNY/Buffalo, NY.

Biederman I, *&* Ju G. (1988). Surface versus edge-based determinants of visual recognition. *Cognitive Psychology, 20,* 38-64.

Bisiach, E. (1966). Perceptual factors in the pathogenesis of anomia. *Cortex, 2,* 90-95.

Blair, I. V., Urland, G. R., *&* Ma, J. E. (2002). Using internet search engines to estimate word frequency. *Behavior Research Methods, Instruments, & Computers, 34 (2),* 286-290.

Bowles, N. L., Obler, L. K., & Albert, M. L. (1987). Naming errors in healthy aging and dementia of the Alzheimer type. *Cortex, 23,* 519-524.

Braak, H., Braak, E., & Kalus, P. (1989). Alzheimer's disease: areal and laminar pathology in the occipital isocortex. *Acta Neuropathology, 77,* 494-506.

Brodie, E. E., Wallace, A. M., & Sharrat, B. (1991). Effect of surface characteristics and style of production on naming and verification of pictorial stimuli. *American Journal of Psychology, 104,* 517-545.

Brooks, R. A. (1981). Symbolic reasoning among 3-D models and 2-D images. *Artificial Intelligence, 17,* 285-348.

Broomhead, D. S., & Lowe, D. (1988). Multivariable functional interpolation and adaptive networks. *Complex Systems, 2,* 321-355.

Brousseau, G., & Buchanan, L. (2004). Semantic category effect and emotional valence in female university students. *Brain and Language, 90,* 241-248.

Brown, G. D. A., & Watson, F. L. (1987). First in, first out: Word learning age and spoken word frequency as predictors of word familiarity and word naming latency. *Memory & Cognition, 15*, 208-216.

Bruner, J. S. (1957). Going beyond the information given. *In: Contemporary approaches to cognition*. Cambridge, MA: Harvard University Press.

Bülthoff, H. H., & Edelman, S. (1992). Psychophysical support for a 2-dimensional view interpolation theory of object recognition. *Proceedings of the National Academy of Sciences of the United States of America, 89*, 60-64.

Bunn, E. M., Tyler, L. K., & Moss, H. E. (1998). Category-specific semantic deficits: The role of familiarity and property type reexamined. *Neuropsychology, 12,* 367-379.

Cameron, R. M., Wambaugh, J. L., & Mauszycki, S. (2008). Effects of age, gender and education on semantic fluency for living and artficat categories. *Aphasiology*, *22,* 790-801.

Capitani, E., Laiacona, M., & Barbarotto, R. (1999). Gender affects Word retrieval of certain categories in semantic fluency tasks. *Cortex*, *35*, 273-278.

Capitani, E., Laiacona, M., Mahon, B., & Caramazza, A. (2003). What are the facts of semantic category specific deficits? A critical review of the clinical evidence. *Cognitive Neuropsychology, 20,* 213-261.

Cappa, S.F., Frugoni, M., Pasquali, P., Perani, D. & Zorat, F. (1998) Category-specific naming impairment for artefacts: A new case. *Neurocase, 4,* 391-397.

Caramazza, A., Hillis, A., Rapp, B., & Romani, C. (1990). The multiple semantics hypothesis: multiple confusions? *Cognitive Neuropsychology, 7*, 161-189.

Caramazza, A., & Mahon, B.Z. (2003). The organization of conceptual knowledge: the evidence from category-specific semantic deficits. *Trends in Cognitive Sciences*, *7*, 325-374.

Caramazza, A., & Shelton, J. R. (1998). Domain-specific knowledge systems in the brain: The animate-inanimate distinction. *Journal of Cognitive Neuroscience, 10*, 1-34.

Carroll, J. B., & White, M. N. (1973). Age-of-acquisition norms for 220 pictureable nouns. *Journal of Verbal Learning and Verbal Behaviour, 12*, 563-576.

Cavanagh, P. (1987). Reconstructing the third dimension: interactions between color, texture, motion, binocular disparity and shape. *Computer Vision, Graphics, and Image Processing, 37,* 171-195.

Chan, A.S., Butters, N., Paulsen, J.S., Salmon, D.P., Swenson, M., & Maloney, L. (1993). An assessment of the semantic network in patients with Alzheimer's disease. *Journal of Cognitive Neuroscience, 5,* 254-261.

Chan, A. S., Salmon, D. P., Butters, N., & Johnson, S. A. (1995). Semantic network abnormality predicts rates of cognitive decline in patients with probable Alzheimer's disease. *Journal of the International Neuropsychological Society, 1,* 297-303.

Chan, A. S., Salmon, D. P., & De la Pena, J., (2001). Abnormal semantic network for "animals" but not "tools" in patients with Alzheimer's disease. *Cortex, 37(2),* 197-217.

Chao, L.L., Haxby, J.V., & Martin, A. (1999). Attribute-based neural substrates in temporal cortex for perceiving and knowing objects. *Nature Neuroscience, 2,* 913-914

Chao, L.L., & Martin, A. (1999). Cortical regions associated with perceiving, naming and knowing about colors. *Journal of Cognitive Neuroscience, 11,* 25-35.

Chertkow, H., & Bub, D. (1990). Semantic memory loss in dementia of Alzheimer's type. *Brain, 113,* 397-417.

Clark, H. H. (1973). The language-as-fixed-effect fallacy: A critique of language statistics in psychological research. *Journal of Verbal Learning and Verbal Behavior, 12,* 335-359.

Collins, A.M., & Quillian, M.R. (1969). Retrieval time from semantic memory. *Journal of Verbal Learning and Verbal Behaviour, 8,* 240-247.

Coppens, P., & Frisinger, D. (2005). Category-specific naming effect in non-brain-damaged individuals. *Brain and Language, 94,* 61-71.

Coyne, A. C., Liss, L. , & Geckler, C. (1984). The relationship between cognitive status and visual information processing. *Journal of gerontology, 39,* 711-717.

Cronin-Golomb, A., Gilmore, G. C., Neargarder, S. A., Morrison, S. R., & Laudate, T. M. (2007). Enhanced stimulus strength improves visual cognition in aging and Alzheimer's disease. *Cortex, 43,* 952-966.

Cronin-Golomb, A., Keane, M. M., Kokodis, A., Corkin, S., & Growdon, J. H. (1992). Category knowledge in Alzheimer's disease: Normal organization and a general retrieval deficit. *Psychology and Aging, 7,* 359-366.

Cronin-Golomb, A., Rizzo, J. F., Corkin, S., Growdon, J. H, (1991). Visual function in Alzheimers disease and normal aging. *Annals of the New York Academy of Sciences 640,* 28–35.

Cronin-Golomb, A., Sugiura, R., Corkin, S., & Growdon, J.H. (1993). Incomplete achromatopsia in Alzheimer's disease. *Neurobiology of Aging, 14*, 471-477.

Crutch, S.J., & Warrington, E.K. (2003). The selective impairment of fruit and vegetable knowledge: A multiple processing channels account of fine-grain category specificity. *Cognitive Neuropsychology, 20*, 355-372.

Coltheart, V., Laxon, V.L., & Keating, C. (1988). Effects of word imageability and age-of-acquisition on children's reading. *The British Journal of Psychology, 79,* 1-12.

Cuetos, F., Dobarro, A., & Martínez , C., (2005). Deterioro de la información conceptual en la enfermedad de Alzheimer. *Neurologia, 20(2),* 58-64.

Cuetos, F., Rosci, C., Laiacona, M., & Capitani, E. (2008). Different variables predict anomia in different subjects: A longitudinal study of two Alzheimer's patients. *Neuropsychologia, 46,* 249-260.

Cummings, J. L., & Benson, D. F. (1992). Dementia: A Clinical Approach (2nd Ed.). Boston: Butterworth-Heinemann.

D'Agostino, R. B., Belanger, A., & D'Agostino, R. B., Jr. (1990). A suggestion for using powerful and informative tests for normality. *The American Statistician, 44,* 316-321.

Daum, I., Riesch, G., Sartori, G., & Birbaumer, N. (1996). Semantic memory impairment in Alzheimer's disease, *Journal of Clinical and Experimental Neuropsychology, 18*, 648-665.

Davidoff, J., & Ostergaard, A., (1988). The role of color in categorical judgements. *Quarterly Journal of Experimental Psychology, 40*, 533-544.

Davidoff, J. B. (1991). *Cognition through colour.* Cambridge MA: MIT Press.

Dell'acqua, R., Lotto, L., *&* Job, R. (2001). Naming times and standardised norms for the Italian PD/DPSS sets of 266 pictures: direct comparisons with American, English, French and Spanish published databases. *Behavior Research Methods, Instruments, & Computers, 32 (4),* 588-615.

Delucchi, K. L., *&* Bostrom, A. (2004). Methods for analysis of skewed data distributions in psychiatric clinical studies: working with many zero values. *American Journal of Psychiatry, 161,* 1159-1168.

DeRenzi, E., & Lucchelli, F. (1994). Are semantic systems separately represented in the brain? The case of living category impairment. *Cortex, 30*, 3-25.

Devlin, J. T., Gonnerman, L. M., Andersen, E. S., & Seidenberg, M. S. (1998). Category-specific semantic deficits in focal and widespread brain damage: A computational account. *Journal of Cognitive Neuroscience 10,* 77-94.

Dixon, M. J., Bub, D. N., & Arguin, M. (1998). Semantic and visual determinants of face recognition in a prosopagnosic patients. *Journal of Cognitive Neuroscience, 10,* 362-376.

Done, D. J., & Gale, T. M. (1997). Attribute verification in dementia of Alzheimer type: Evidence for the preservation of distributed concept knowledge. *Cognitive Neuropsychology, 14,* 547-571.

Dordain, M., Nespoulos, J. L., Bourdeau, M., Lecours, A. R. (1983). Verbal performance of normal adults subjected to a language test for aphasics. *Acta Neurologica Belgica, 83,* 5-16.

Duarte, L. R., Marquié, L., Marquié, J. C., Terrier, P., Oussett, P. J. (2009). Analyzing feature distinctiveness in the processing of living and non-living concepts in Alzheimer's disease. *Brain and Cognition,* in press.

Dudas, R. B., Clague, F., Thompson, S. A., Graham, K. S., & Hodges, J. R. (2005). Episodic and semantic memory in mild cognitive impairment. *Neuropsychologia, 43,* 1266-1276.

Durrant-Peatfield, M.R., Tyler, L.K., Moss, H.E., & Levy, J.P. (1997). The distinctiveness of form and function in category structure: a connectionist model. In M.G. Shafto & P. Langley (Eds.), *Proceedings Of The Nineteenth Conference of The Cognitive Science Society.* Malwah, NJ: Lawrence Erlbaum Associates Inc.

Edelman, S. (1993) Representing 3D objects by sets of activities of receptive fields. *Biological Cybernetics, 70,* 37-45.

Edelman. S., & Bülthoff, H. H. (1992). Orientation dependence in the recognition of familiar and novel views of three-dimensional objects. *Vision Research, 12,* 2385-2400.

Edelman, S., Bülthoff, H. H., & Bülthoff, I. (1999). Effects of parametric manipulation of inter-stimulus similarity on 3-D object categorization. *Spatial Vision, 12,* 107-123.

Ellis, A. W., & Young, A. W. (1996). *Human cognitive neuropsychology: A textbook with readings*. Hove, UK: Psychology Press.

Etcoff, N. L., Freeman, R., & Cave, K. R. (1991). Can we lose memories of faces? Content specificity and awareness in a prosopagnosic. *Journal of Cognitive Neuroscience, 3,* 25-41.

Farah, M. J., Hammond, K. M., Mehta, Z., & Ratcliff, G. (1989). Category-specificity and modality-specificity in semantic memory. *Neuropsychologia 27,*193-200.

Farah, M. J., & McClelland, J. L. (1991). A computational model of semantic memory impairment: Modality-specificity and emergent category-specificity. *Journal of Experimental Psychology: General, 120,* 339-357.

Farah, M. J., McMullen, P. A., & Meyer, M. M., (1991). Can recognition of living things be selectively impaired? *Neuropsychologia, 29*, 185-193.

Farah, M. J., & Wallace, M. A. (1992). Semantically-bounded anomia: Implications for the neural implementation of naming. *Neuropsychologia, 30,* 609–621.

Farmer, A. (1990). Performance of normal males on the Boston Naming Test and the Word Test. *Aphasiology, 4,* 293-296.

Ferri, C. P., Prince, M., Brayne, C., Brodaty, H., Fratiglioni, L., Ganguli, M., Hall, K., Hasegawa, K., Hendrie, H., Huang, Y., Jorm, A., Mathers, C., Menezes, P. R., Rimmer, E., Scazufca, M., & for Alzheimer's Disease International. (2005). Global prevalence of dementia: a Delphi consensus study. *The Lancet, 366,* 2112-2117.

Fery, P & Morais J. (2003). A case study of visual agnosia without perceptual processing or structural descriptions impairment. *Cognitive Neuropsychology, 20,* 595-618.

Filliter, J. H., McMullen, P. A., & Westwood, D. (2005). Manipulability and living/non-living category effects on object identification. *Brain and Cognition*, *57,* 61-65.

Folstein, M. F., Folstein, S. E., & McHugh, P. R., (1975). Mini-mental state: a practical guide for grading the mental state of patients for the clinician. *Journal of Psychiatric Research, 12,* 189-198.

Forde, E. M. E., Francis, D., Riddoch, M. J., Rumiati, R. I., & Humphreys, G. W. (1997). On the links between visual knowledge and naming: A single case study of a patient with a category-specific impairment for living things. *Cognitive Neuropsychology, 14*, 403-458.

Frederiksen, J. R., & Kroll, J. F. (1976). Spelling and sound: Approaches to the internal lexicon. *Journal of Experimental Psychology, Human Perception and Performance, 2,* 361-379.

Fung, T. D., Chertkow, H., Murtha, S., Whatmough, C., Peloquin, L., Whitehead, V., & Templeman, F. D., (2001). The spectrum of category effects in object and action knowledge in dementia of the Alzheimer's type. *Neuropsychology, 15 (3),* 371-379.

Funnell, E. (2000). Apperceptive agnosia and the visual recognition of object categories in dementia of the Alzheimer type. *Neurocase, 6,* 451-463.

Funnell, E., Hughes, D., & Woodcock, J. (2006). Age of acquisition for naming and knowing: A new hypothesis. *The Quarterly Journal of Experimental Psychology, 59, 268-295.*

Funnell, E., & Sheridan, J. (1992). Categories of knowledge? Unfamiliar aspects of living and nonliving things. *Cognitive Neuropsychology, 9,* 135-153.

Gaffan, D., & Heywood, A. (1993). A spurious category-specific visual agnosia for living things in normal humans and nonhuman primates. *Journal of Cognitive Neuroscience, 5,* 118-128.

Gainotti, G. (2000). What the locus of brain lesions tells us about the nature of the cognitive defect underlying category-specific disorders: A review. *Cortex*, *36,* 539-559.

Gainotti, G. (2005). The influence of gender and lesion location on naming disorders for animals, plants and artefacts. *Neuropsychologia, 43,* 1633-1644.

Gainotti, G., Daniele, A., Nocentini, U., & Silveri, M. C. (1989). The nature of lexical-semantic impairment in Alzheimer's disease. *Journal of Neurolinguistics, 4,* 449-460.

Gainotti, G., & Silveri, M. (1996). Cognitive and anatomical locus of lesion in a patient with a category-specific semantic impairment for living beings. *Cognitive Neuropsychology*, *13*, 357-389.

Gale, T. M., Done, D. J., & Frank, R. J. (2001). Visual crowding and category specific deficits for pictorial stimuli: A neural network model. *Cognitive Neuropsychology, 18,* 509-550.

Gale, T.M., Irvine, K., Laws, K.R & Ferrissey, S. (2009). The naming profile in Alzheimer patients parallels that of elderly controls. *Journal of Clinical and Experimental Neuropsychology*, *31*, 565-574.

Gale, T. M., Laws, K. R., & Foley, K. (2006). Crowded and sparse domains in object recognition: consequences for categorisation and naming. *Brain and Cognition*, *60*, 139-145.

Garrard, P., Lambon-Ralph, M., Watson, P., Powis, J., Patterson, K., & Hodges, J. (2001). Longitudinal profiles of semantic impairments for living and nonliving concepts in dementia of Alzheimer's type. *Journal of Cognitive Neuroscience*, *13*, 892-909.

Garrard, P., Patterson, K., Watson, P. C., & Hodges, J. R. (1998). Category specific semantic loss in dementia of Alzheimer's type. Functional-anatomical correlations from cross-sectional analyses. *Brain*, *121,* 633-646.

Gaulin, S., Krasnow, M., Truxaw, D., & New, J. (2005). An ecologically valid foraging task yields a female spatial advantage and significant content effects. *Paper presented at the annual meeting of the Human Behavior and Evolution Society*, *June 1-5, 2005*, *Austin TX.*

Geary, D. C. (1998). *Male, female: the evolution of human sex differences.* Washington, DC: American Psychological Association.

Gegenfurtner, K. R., & Rieger, J. (2000). Sensory and cognitive contributions of color to the recognition of natural scenes. *Current Biology, 10,* 805-808.

Gerlach, C. (2001). Structural similarity causes different category-effects depending on task characteristics. *Neuropsychologia*, *39*, 895-900.

Gerlach, C. (2009). Category-specificity in visual object recognition. *Cognition,* in press.

Gerlach, C., Law, I., Gade, A & Paulson, O.B. (1999). Perceptual differentiation and category effects in normal object recognition – a PET study. *Brain, 122*, 2159-2170.

Gerlach, C., Law, I., & Paulson, O. B. (2004). Structural similarity and category specificity: a refined account. *Neuropsychologia, 42,* 1543-1553.

Gerlach, C., Law, I., & Paulson, O. B. (2006). Shape configuration and category-specificity. *Neuropsychologia, 44,* 1247-1260.

Gernsbacher, M. A. (1984). Resolving 20 years of inconsistent interactions between lexical familiarity and orthography, concreteness, and polysemy. *Journal of Experimental Psychology, General, 113*, 256-281.

Gibson, E. J. (1969). *Principles of Perceptual Learning and Development.* New York: Appleton-Century-Crofts.

Gilhooly, K. J., & Gilhooly, M. L. (1979). Age-of-acquisition effects in lexical and episodic memory tasks. *Memory & Cognition*, *7*, 214-223.

Gilhooly, K. J., & Logie, R. H. (1981). Word age-of-acquisition, reading latencies and auditory recognition. *Current Psychological Research, 1*, 251-262.

Gilhooly, K. J., & Logie, R. H. (1982). Word age-of-acquisition and lexical decision-making. *Acta Psychologica*, *50,* 21-34.

Gilmore, G. C., Cronin-Golomb, A., Neargarder, S. A., & Morrison, S. R. (2005a). Enhanced stimulus contrast normalizes visual processing of rapidly presented letters in Alzheimer's disease. *Vision Research, 45,* 1013-1020.

Gilmore, G.C., Groth, K.E., & Thomas, C. W. (2005b) Stimulus contrast and word reading speed in Alzheimer's disease. *Experimental Aging Research*, *31*, 15-33.

Gilmore, G. C., & Levy, J. A. (1991). Spatial contrast sensitivity in Alzheimer's disease: a comparison of two methods. *Optometry and Vision Science, 68,* 790-794.

Gitelman, D. G., Ashburner, J., Friston, K. J., Tyler, L. K., & Price, C. J. (2001). Voxel-based morphometry of herpes simplex encephalitis. *Neuroimage, 13,* 623-631.

Gonnerman , L., Anderson, E., Devlin, J., Kempler, D., & Seidenberg, M. (1997). Double dissociation of semantic categories in Alzheimer's disease. *Brain and Language, 57,* 254-279.

Goulet, P., Ska, B., & Kahn, H. J. (1994). Is there a decline in picture naming with advancing age. *Journal of Speech and Hearing Research, 37,* 629-644.

Grill-Spector, K., Kushnir, T., Hendler, T., & Malach, R. (2000). The dynamics of object-selective activation correlate with recognition performance in humans. *Nature Neuroscience, 3,* 837-843.

Grimson, W. E. L. (1989). On the recognition of parameterized 2-D objects. *International Journal of Computer Vision, 2,* 353-372.

Grossman, M., Galetta, S., & D'Esposito, M. (1997). Object recognition difficulty in apperceptive agnosia. *Brain and Cognition, 33 (3),* 306-342.

Grossman, M., McMillan, C., Moore, P., Ding, L., Glosser, G., Work, M., & Gee, J. (2004). What's in a name: Voxel-based morphometric analyses of MRI and naming difficulty in Alzheimer's disease, frontotemporal dementia and corticobasal degeneration. *Brain, 127,* 628-649.

Grossman, M., Robinson, K., Biassou, N., White-Devine, T., & D'Esposito, M. D., (1998). Semantic memory in Alzheimer's disease: representativeness, ontologic category, and material. *Neuropsychology, 12(1),* 34-42.

Hamby, S.L., Bardi, C.A., & Wilkins J.W. (1997) Neuropsychologica l assessment of relatively intact individuals: Psychometric lessons from a HIV+ sample. *Archives of Clinical Neuropsychology, 12,* 545–556.

Harley, T. A., & Grant, F. (2004). The role of functional and perceptual attributes: evidence from picture naming in dementia. *Brain and Language, 91,* 223-234.

Hart, J., Berndt, R. S., & Caramazza, A. (1985). Category-specific naming deficit following cerebral infarction. *Nature, 316,* 439-440.

Hart, J. & Gordon, B. (1992). Neural subsystems for object knowledge. *Nature, 359,* 60-64.

Hart, S. (1988). Language and dementia: A review. *Psychological Medicine, 18,* 99-112.

Hawkins, K.A., & Bender, S. (2002). Norms and the relationship of Boston Naming Test performance to vocabulary and education: A review. *Aphasiology*, *16*, 1143-1153.

Haxby, J. V., Ungerleider, L. G., Clark, V. P., Schouten, J. L., Hoffman, E. A., & Martin, A. (1999). The effect of face inversion on activity in human neural systems for face and object perception. *Neuron, 22,* 189-199.

Hedges, L. V., & Olkin, I. (1985). *Statistical Methods for Meta-analysis.* New York: Academic Press.

Henderson, V. W., & Finch, C. E. (1989). The neurobiology of Alzheimers-disease. *Journal of Neurosurgery, 70,* 335-353.

Hernández, M., Costa, A., Juncadella, M., Sebastián-Gallés, & Reñe, R. (2008). Category-specific semantic deficits in Alzheimer's disease: A semantic priming study. *Neuropsychologia, 46,* 935-946.

Hillis, A., & Caramazza, A. (1991). Category-specific naming and comprehension impairment: A double dissociation. *Brain, 114*, 2081-2094.

Hillis, A. E., Rapp, B., & Caramazza, A. (1995). Constraining claims about theories of semantic memory - more on unitary versus multiple semantics. *Cognitive Neuropsychology, 12,* 175-186.

Hodges, J., & Patterson, K. (1995). Is semantic memory consistently impaired early in the course of Alzheimer's disease: Neuroanatomical and diagnostic implications. *Neuropsychologia, 33,* 441-459.

Hodges, J., Patterson, K., Graham, N., & Dawson, K. (1996). Naming and knowing in dementia of Alzheimer's type. *Brain and Language, 54,* 302-325.

Hodges, J. R., Salmon, D. P., & Butters, N. (1991). The nature of the naming deficit in Alzheimers and Huntingtons-disease. *Brain, 114,* 1547-1558.

Hodges, J. R., Salmon, D. P., & Butters, N. (1992). Semantic memory impairment in Alzheimer's: Failure of access or degraded knowledge? *Neuropsychologia, 30,* 301-314.

Hodgson, C., & Ellis, A.W. (1998). Last in, first to go: AoA and naming in the elderly. *Brain and Language, 64,* 146-163.

Holmes, S., Fitch, F.J., & Ellis, A. (2006). Age of acquisition affects object recognition and naming in patients with Alzheimer's disease. *Journal of Clinical and Experimental Neuropsychology, 28,* 1010 – 1022.

Holroyd, S., & Shepherd, M. L. (2001). Alzheimer's disease: a review for the ophthalmologist. *Survey of Ophthalmology, 45,* 516–24.

Huff, F. J., Corkin, S., & Growden, J. (1986). Semantic impairment and anomia in Alzheimer's disease. *Brain and Language*, *28*, 235-249.

Hummel, J. E., & Biederman, I. (1992). Dynamic binding in a neural network for shape recognition. *Psychological Review, 99,* 480-517.

Humphrey, G. K., Goodale, M. A., Jakobson, L. S., & Servos, P., (1994). The role of surface recognition in object perception: studies of visual form agnosic and normal subjects. *Perception, 23,* 1457-1481.

Humphreys, G. W., Lamote, C., & Lloyd-Jones, T. J. (1995). An interactive activation approach to object processing: effect of structural similarity, name frequency, and task in normality and pathology. *Memory, 3,* 535-586.

Humphreys, G. W., & Riddoch, M. J. (1987). *To see but not to see: a case study of visual agnosia.* London: Erlbaum.

Humphreys, G. W., Riddoch, M. J., & Quinlan, P. T. (1988). Cascade processes in picture identification. *Cognitive Neuropsychology, 5,* 67-103.

Huttenlocher, D. P., & Ullman, S. (1990). Recognizing solid objects by alignment with an image. *International Journal of Computer Vision, 5,* 195-212.

Ishihara S. (1973). *Tests for Colour-Blindness.* Tokyo, Japan: Kanehara Shuppan Co., Ltd.

Ivnik, R. J., Malec, J. F., Smith, G. E., Tangalos, E. G., & Peterson, R. C. (1996). Neuropsychological tests' norms above age 55: COWAT, BNT, M. A. E. Token, WRAT-R Reading, AMNART, Stroop, TMT, and JLO. *The Clinical Neuropsychologist*, *10,* 262–278.

James, T. W., Humphrey, G. K., Gati, J. S., Menon, R. S., & Goodale, M. A. (2000). The effects of visual object priming on brain activation before and after recognition. *Current Biology, 10,* 1017-1024.

James, M., Plant, G.T., & Warrington, E. K. (2001). *Cortical Visual Screening Test.* Bury St Edmonds, UK: Thames Valley Test Company.

Joseph, J. E., & Gathers, A. D. (2003). Effects of structural similarity on neural substrates for object recognition. *Cognitive, Affective, and Behavioural Neuroscience, 3,* 1-16.

Joubert, S., Felician, O., Barbeau, E. J., Didic, M., Poncet, M., & Ceccaldi, M. (2008). Patterns of semantic memory impairment in Mild Cognitive Impairment. *Behavioural Neurology, 19,* 35-40.

Kaplan, E., Goodglass, H., & Weintraub, S. (1976). *Boston Naming Test. Experimental Edition*. Boston: Aphasia Research Center, Boston University

Kavé, G. (2005). Standardization and norms for a Hebrew naming test.*Brain and Language, 92*, 204–211.

Kavé, G., Samuel-Enoch, K., & Adiv, S. (2009). The association between age and the frequency of nouns selected for production. *Psychology and Aging, 24*, 17-27.

Kay, J., & Hanley, J. R. (1999). Person-specific knowledge and knowledge of biological categories. *Cognitive Neuropsychology, 16,* 171-180.

Kent, P., & Luszcz, M. A. (2002). A review of Boston and multiple occasion normative data for older adults on 15-item versions. *The Clinical Neuropsychologist, 16*, 555-574.

Kiefer, M. (2001). Perceptual and semantic sources of category-specific effects: Event-related potentials during picture and word categorization. *Memory and Cognition, 29,* 100-116.

Kirshner, H. S., Webb, W. G., & Kelly, M. D. (1984). The naming disorder of dementia. *Neuropsychologia, 22*, 23-30.

Kitterle, F. L., & Christman, S. (1991). Symmetries and asymmetries in the processing of sinusoidal gratings. In Kitterle FL, editor. *Cerebral laterality: Theory and research.* Hillsdale, NJ: Erlbaum, 1991: 201-224.

Köhler, S., Moscovitch, M., Winocur, G., *&* McIntosh, A. R. (2000). Episodic encoding and recognition of pictures and words: role of human medial temporal lobes. *Acta Psychologica, 105*, 159-179.

Kolinsky, R., Fery, P., Messina, D., Peretz, I., Evinck, S., Ventura, P., & Morais, J. (2002). The fur of the crocodile and the mooing sheep: A study of a patient with a category-specific impairment for biological things. *Cognitive Neuropsychology, 19,* 301-342.

Krackow, E., & Gordon, P. (1998). Are lions and tigers substitutes or associates? Evidence against slot-filler accounts of children's early categorization. *Child Development, 69,* 347-354.

Kučera, H., *&* Francis, W. (1967). *Computational analysis of present-day American English Providence.* Rhode Island: Brown University Press.

Kurylo, D. D., Corkin, S., Dolan, R. P., Rizzo, J. F., 3rd, Parker, S. W., & Growdon, J. H. (1994). Broad-band visual capacities are not selectively impaired in Alzheimer's disease. *Neurobiology of Aging, 15,* 305-311.

Kurylo, D. D., Corkin, S., & Growdon, J. H. (1994). Perceptual organisation in Alzheimer’s disease. *Psychology of Aging, 9*, 562-567.

LaBarge, E., Edwards, D., & Knesevich, J. W. (1986). Performance of normal elderly on the Boston naming test. *Brain and Language,* 27, 380-384.

Lachman, R., Shaffer, J. P., & Hennriku, D. (1974). Language and cognition: Effects of stimulus codability, name-work frequency, and age of acquisition on lexical reaction-time. *Journal of verbal learning and verbal behaviour, 13,* 613-625.

Låg, T., (2005). Category-specific effects in object identification: what is ‘normal’? *Cortex, 41*, 842-851.

Låg, T., Hveem, K., Ruud, K. P. E., & Laeng, B. (2006). The visual basis of category effects in object identification: Evidence from the visual hemifield paradigm. *Brain and Cognition, 60,* 1-10.

Laiacona, M., Barbarotto, R., & Capitani, E. (1998). Semantic category dissociations in naming: is there a gender effect in Alzheimer’s disease. *Neuropsychologia, 36*, 407-419.

Laiacona, M., Barbarotto, R., & Capitani, E., (2006). Human evolution and the brain representation of semantic knowledge: is there a role for sex differences? *Evolution and Human Behavior, 27,* 158-168.

Laiacona, M., Barbarotto, R., Trivelli, C., & Capitani, E. (1993). Disossociazioni semantiche intercategoriali: descrizione di una batteria standrdizzata e dati normativi. *Archivio di Psicologia, Neurologia e Psichiatria, 54,* 209-248.

Laiacona, M. & Capitani, E. (2001) A case of prevailing deficit of nonliving categories or a case of prevailing sparing of living categories? *Cognitive Neuropsychology, 18,* 39-70.

Laiacona M, Capitani E & Barbarotto R. (1997). Semantic category dissociations: A longitudinal study of two cases. *Cortex, 33,* 441-461.

Laiacona, M., Luzzatti, C., Zonca, G., Guarnaschelli, C., & Capitani, E. (2000). Lexical and semantic factors influencing picture naming in aphasia. *Brain and Cognition, 46*, 184-187.

Lambon Ralph, M. A., Howard, D., Nightingale, G., & Ellis, A. W. (1998). Are living and non-living category-specific deficits causally linked to impaired perceptual or associative knowledge? Evidence from a category-specific double dissociation. *Neurocase, 4,* 311–338.

Lambon Ralph, M.A., Patterson, K., & Hodges, J.R. (1997). The relationship between naming and semantic knowledge for different categories in dementia of Alzheimer’s type. *Neuropsychologia, 35*, 251-1260.

Laws, K. R., (1999). Gender affects naming latencies for living and non-living things: implications for familiarity. *Cortex*, *35*, 729-733.

Laws, K. R. (2000). Category-specific naming errors in normal subjects: the influence of evolution and experience. *Brain and Language, 75*, 123-133.

Laws, K.R. (2002) Category-specificity and imagery vividness in different modalities. *Brain and Cognition, 48*,418-420.

Laws, K. R. (2003). Sex differences in lexical size across semantic categories. *Personality and Individual Differences*, *36,* 23-32.

Laws, K. R., (2004). Gender differences in lexical size across categories. *Personality and Individual Differences, 36,* 23-32.

Laws, K. R. (2005). Illusions of normality: a methodological critique of category-specific naming. *Cortex*, *41*, 842-851.

Laws, K. R., Adlington, R. L., Gale, T. M., Moreno-Martínez, F. J., & Sartori, G., (2007a). Meta analysis of category naming in Alzheimer's disease. *Neuropsychologia*, *45*, 2674-2682.

Laws, K. R., Crawford, J. R., Gnoato, F., & Sartori, G. (2007b). A *predominance of category deficits for living things in Alzheimer's disease and Lewy Body dementia. Journal of the International Neuropsychological Society*, *13*, 401-409.

Laws, K. R., Evans, J. J., Hodges, J. R., & McCarthy, R. A. (1995). Naming without knowing and appearance without associations: Evidence for constructive processes in semantic memory. *Memory*, *3*, 409-433.

Laws, K. R., *&* Gale, T. M. (2002). Category-specific naming and the 'visual' characteristics of line drawn stimuli, *Cortex, 38*, 7-21.

Laws, K. R., Gale, T. M., Frank, R. J., & Davey, N. (2002). Visual similarity is greater for line drawings of nonliving things: the importance of musical instruments and body-parts. *Brain and Cognition, 48,* 421-423.

Laws, K. R., Gale, T. M., Leeson, V. C., & Crawford, J., (2005). When is category specific in Alzheimer's disease? *Cortex, 41*, 452-463.

Laws, K.R., Gale, T.M., Leeson, V.C., & Davey, N. (2003). The influence of surface and edge-based visual similarity on object recognition. *Brain and Cognition, 53*, 232-234.

Laws, K. R., & Hunter, M. Z., (2006). The impact of colour, spatial resolution, and presentation speed on category naming. *Brain and Cognition, 62*, 89-97.

Laws, K.R., Leeson, V.C., & Gale, T.M. (2002a). The effect of 'masking' on picture naming latencies. Cortex, 38, 137-147.

Laws, K. R., Leeson, V. C., & Gale, T. M. (2002b). A domain-specific deficit for foodstuffs in patients with Alzheimer's disease. Journal of the International Neuropsychological Society, 8, 956-957.

Laws, K. R., & Neve, C. (1999). A 'normal' category-specific advantage for naming living things. *Neuropsychologia, 37,* 1263-1269.

Laws, K. R., & Sartori, G. (2005). Category deficits and paradoxical dissociations in Alzheimer's disease and herpes simplex encephalitis. *Journal of Cognitive Neuroscience, 17,* 1453-1459.

Le Dorze, G. & Durocher, J. (1992). The effeccts of age, educational level, and stimulus length on naming in normal subjects. *Journal of Speech Language Pathology and Audiology, 16,* 21-29.

Lewis, D. A., Campbell, M. J., Terry, R. D., & Morrison, J. H. (1987). Laminar and regional distributions of neurofibrillary tangles and neuritic plaques in Alzheimer's disease: a quantitative study of visual and auditory cortices. *Journal of Neuroscience, 7,* 1799-1808.

Lloyd-Jones, T. J., & Humphreys, G. W. (1997). Perceptual differentiation as a source of category effects in object processing: evidence from naming and object decision. *Memory and Cognition, 25,* 18-35.

Lloyd-Jones, T. J., & Luckhurst, L. (2002). Outline shape is a mediator of object recognition that is particularly important for living things. *Memory and Cognition, 30,* 489-498.

Lowe, D. (1987). Three-dimensional object recognition from single two-dimensional images. *Artificial Intelligence, 31,* 355-395.

Lucariello, J., Kyratzis, A., & Nelson, K. (1992). Taxonomic knowledge: What kind and when? *Child Development, 63,* 978-998.

Luzziatti, C., & Davidoff, J. (1994). Impaired retrieval of object-colour knowledge with preserved colour naming. *Neuropsychologia, 32,* 933-950.

Mahon, B. Z., & Caramazza, A. (2003). Constraining questions about the organisation and representation of conceptual knowledge. *Cognitive Neuropsychology, 20,* 433-450.

Mapelli, D., & Behrmann, M., (1997). The role of colour in object recognition: evidence from visual agnosia. *Neurocase*, *3*, 237-247.

Markoff, J. I., (1972). Evaluation of chromatic displays as a function of observer adaptation level. *Sid. International Symposium Digest of Technical Papers, 11,* 40.

Marr, D. (1982). *Vision.* New York: Freeman.

Marr, D., & Nishihara, H. K. (1978). Representation and recognition of the spatial organization of three-dimensional shapes. *Proceedings of the Royal Society of London, Series B, 200,* 269-294.

Marra, C., Ferraccioli, M., & Gainotti, G., (2007). Gender-related dissociations of categorical fluency in normal subjects and in subjects with Alzheimer's disease. *Neuropsychology, 21 (2),* 207-211.

Martin A. (1992). Degraded knowledge representations in patients with Alzheimer's disease: implications for models of semantic and repetition priming. In: Squire L, Butters N editors. Neuropsychology of memory. New York: Guilford Press, p. 220–32.

Martin, A., & Fedio, P. (1983). Word production and comprehension in Alzheimer's disease: the breakdown of semantic knowledge. *Brain and Language*, *19*, 124-141.

Martin, A., Haxby, J. V., Lalonde, F. M., Wiggs, C. L., & Ungerleider, L.G. (1995). Discrete cortical regions associated with knowledge of color and knowledge of action. *Science, 270,* 102–105.

Martin A., & Weisberg, J. (2003). Neural foundations for understanding social and mechanical concepts. *Cognitive Neuropsychology*, *20*, 575-587.

Martin, A., Wiggs, C. L., Altemus, M., Rubenstein, C., & Murphy, D. L. (1995). Working-memory as assessed by subject-ordered tasks in patients with obsessive-compulsive disorder. *Journal of Clinical and Experimental Neuropsychology, 17*, 786-792.

Martin, A., Wiggs, C.L., Ungerleider, L.G., & Haxby, J.V (1996). Neural correlates of category-specific knowledge. *Nature, 379*, 649-652.

Mauri, A., Daum, I., Sartori, G., Riesch, G., & Birbaumer, N., (1994). Category-specific semantic impairment in Alzheimer's disease and temporal lobe dysfunction: a comparative study. *Journal of Clinical and Experimental Neuropsychology, 16,* 689-701.

McBurney, D. H., Gaulin, S. J. C., Devineni T., & Adams, C. (1997). Superior spatial memory of women: Stronger evidence for the gathering hypothesis. *Evolution and Human Behavior, 18,* 165-174.

McCarthy, R. A., & Warrington, E. K. (1988). Evidence for modality-specific meaning systems in the brain. *Nature, 334,* 428–430.

McKee, A. C., Au, R., Cabral, H. J., Kowall, N. W., Seshadri, S., Kubilus, C. A., Drake, J., & Wolf, P. A. (2006). Visual association pathology in preclinical Alzheimer's disease. *Journal of Neuropathology and Experimental Neurology, 65,* 621-630.

McKenna, P., & Parry, R. (1994). Category-specificity in the naming of natural and man-made objects. *Neuropsychological Rehabilitation, 4,* 255-281.

McRae, K. (1992). Correlated properties in artifact and natural kind concepts. In *Proceedings of the Fourteenth Annual Conference of the Cognitive Science Society.* Hillsdale, NJ: Lawrence Erlbaum Associates, pp 349-354.

McRae, K., & Cree, G. S. (2002). Factors underlying category-specific semantic deficits. In E. M. E. Forde and G. W. Humphreys (Eds.), *Category-Specificity in Brain and Mind*. (pp. 211-249). East Sussex, UK: Psychology Press.

Miceli, G., Capasso, R., Daniele ,A., Esposito, T., Magarelli, M., & Tomaiuolo, F. (2000). Selective deficit for people's names following left temporal damage: An impairment of domain-specific conceptual knowledge. *Cognitive Neuropsychology, 17,* 489-516.

Miceli, G., Fouch, E., Capasso, R., Shelton, J. R., Tomaiuolo, F., & Caramazza, A. (2001). The dissociation of color from form and function knowledge. *Nature Neuroscience, 4,* 662-667.

Miller E. (1977). A note on visual information processing in presenile dementia: a preliminary report. *British Journal of Social and Clinical Psychology, 16,* 99-100.

Mitchell, D. B. (1989). How many memory systems? Evidence from aging. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15***,** 31–49.

Mondini, S., Borgo, F., Cotticelli, B., & Bisiacchi, P. (2006). Progressive knowledge loss: A longitudinal case study. *Journal of the International Neuropsychological Society, 12,* 275-284.

Monsell, S., Doyle, M. C., Haggard, P. N. (1989). Effects of frequency on visual word recognition tasks-where are they. *Journal of Experimental Psychology, General, 118,* 43-71.

Montanes, P., Goldblum, M. C., & Boller, F. (1995). The naming impairment of living and nonliving items in Alzheimer's disease. *Journal of the International Neuropsychological Society, 1,* 39-48.

Montgomery, K.M., & Costa, L. (1983). *Neuropsychological test performance of a normal elderly sample*. Paper presented at the International Neuropsychological Society Meeting, Mexico City.

Moore, C.J. & Price, C.J. (1999). A functional neuroimaging study of the variables that generate category-specific object processing differences. *Brain, 122,* 943-962.

Moreno-Martínez, F.J., & Laws, R.K. (2007). An attenuation of the 'normal' category effect in patients with Alzheimer's disease: A review and bootstrap analysis. *Brain and Cognition, 63,* 136-142.

Moreno-Martínez, F. J., & Laws, K. R. (2008). No category specificity in Alzheimer's disease: A normal aging effect. *Neuropsychology, 22,* 485-490.

Moreno-Martínez, F. J., Laws, K. R., Goñi-Imizcoz, M., & Sanchez Martínez, A. (2008). The longitudinal neurodegenerative impact of Alzheimer's disease on picture naming. In H. S. Jeong (Ed) *Alzheimer's Disease in the Middle-Aged.* Nova Science Publishers, Inc.

Moreno-Martínez, F. J., Laws, K. R., & Schulz, J. (2008). The impact of dementia, age and sex on category fluency: Greater deficits in women with Alzheimer's disease. *Cortex, 44,* 1256-1264.

Moreno-Martínez, F.J., & Peraita, H. (2007). Un nuevo conjunto de ítems para la evaluación de la disociación ser vivo / ser no vivo con normas obtenidas de ancianos sanos españoles (A new set of ítems for the evaluation of living/nonliving dissociations with norms collected from healthy elderly Spanish). *Psicológica, 28,* 1-20.

Moreno-Martínez, F. J., Tallón-Barranco, A., & Frank-Garcia, A., (2007). Enfermedad de Alzheimer, deterioro categorical y variables relevantes en la denominación de objetos. *Revista de Neurologia, 44,* 129-133.

Moss, H. E., & Tyler, L. K. (1997). A category-specific semantic deficit for nonliving things in a case of progressive aphasia. *Brain and Language, 60,* 55-58.

Moss, H. E., & Tyler, L. K. (2000). A progressive category-specific semantic deficit for non-living things. *Neuropsychologia, 38(1),* 60-82.

Moss, H. E., & Tyler, L. K. (2003). Weighing up the facts of category-specific semantic deficits: A reply to Caramazza & Mahon. *Trends in Cognitive Sciences, 7*(11), 480-481.

Moss, H. E., Tyler, L. K., & Devlin, J. T. (1999). *Modelling progressive impairments of semantic memory: Interactions between severity and domain of knowledge.* Paper presented to the British Neuropsychological Society, London, 1999.

Moss, H. E., Tyler, L. K., Durrant-Peatfield, M., & Bunn, E. M. (1998). Two eyes of a see-through: Impaired and intact semantic knowledge in a case of selective deficit for living things. *Neurocase, 4,* 291–310.

Moss, H. E., Tyler, L. K., Hodges, J. R., & Patterson, K. (1995). Exploring the loss of semantic memory in semantic dementia: Evidence from a primed monitoring study. *Neuropsychology, 9*, 16-26.

Moss, H. E., Tyler, L. K., & Jennings, F. (1997). When leopards lose their spots: Knowledge of visual properties in category-specific deficits for living things. *Cognitive Neuropsychology, 14,* 901–950.

Mummery, C.J., Patterson, K., Hodges, J.R., & Price, C.J. (1998). Functioanl neuroanatomy of the semantic system: divisible by what? *Journal of Cognitive Neuroscience, 10*, 766-777.

Mummery, C.J., Patterson, K., Price, C. J., Ashburner, J., Frackowiak, R. S. J., & Hodges, J. R. (2000). A voxel-based morphometry study of semantic dementia: Relationship between temporal lobe atrophy and semantic memory. *Annals of Neurology,47,* 36-45.

Nebes, R. D. (1989). Semantic memory in Alzheimers-disease. *Psychological Bulletin, 106,* 377-394.

Nebes, R. D., Boller, F., & Holland, A. (1986). The use of semantic context by patients with Alzheimer's disease. *Psychology and Aging, 1*, 261-269.

Nebes, R. D., & Brady, C. B. (1990). Preserved organization of semantic attributes in Alzheimer's disease. *Psychology and Aging, 5,* 574-579.

Nebes, R. D., Martin, D. C., & Horn, L. C. (1984). Sparing of semantic memory in Alzheimer's disease. *Journal of Abnormal Psychology, 93,* 321-330.

Neils, J., Baris, J. M., Carter, C., Dell'aira, A. L. Nordloh, S. J., Weiler, E., & Weisiger, B. (1995). Effects of age, education, and living environment on Boston Naming Test performance. *Journal of Speech and HearingResearch, 38,* 1143–1149.

Nelson, H. E. (1982). National Adult Reading Test (NART): Test Manual, NFER-Nelson, Windsor.

Nelson, K. (1996) Language in Cognition: The Emergence of the Mediated Mind. Cambridge University Press.

Nielsen, J.M. (1946). *Agnosia, Apraxia: Their Value in Cerebral Localization*, 2nd Edn (New York: Hoeber).

Nissen, M. J., Corkin, S., Buonanno, F. S., Growdon, J. H., Wray, S. H., & Bauer, J. (1985). Spatial vision in Alzheimers disease: general findings and a case report. *Archives of Neurology, 42,* 667-671.

Ober, B. A, & Shenaut, G. K. (2003). New directions in the study of semantic deficits: A comment on Storms et al. (2003). *Neuropsychology, 17,* 315-317.

Ober, B. A., Shenaut, G. K., & Reed, B. R. (1995). Assessment of associative relations in Alzheimer's disease: Evidence for preservation of semantic memory. *Aging, Neuropsychology, and Cognition, 2,* 254-267.

Oldfield, R. C., & Wingfield, A. (1965). Response latencies in naming objects. *The Quarterly Journal of Experimental Psychology, 17,* 273-281.

Oliva, A., & Schyns, P., (2000). Diagnostic colors mediate scene recognition. *Cognitive Psychology, 41*, 176-210.

Op de Beeck, H., Beatse, E., Wagemans, J., Sunaert, S., & Van Hecke, P., (2000). The representation of shape in the context of visual object categorization tasks. *Neuroimage, 12 (1),* 28-40.

Ostergaard, A. L., & Davidoff, J. B., (1985). Some effects of colour on naming and recognition of objects. *Journal of Experimental Psychology: Learning, Memory and Cognition. 11*, 579-587.

Ousset, P. J., Viallard, G., Puel, M., Celsis, P., Demonet, J. F., & Cardebat, D. (2002). Lexical therapy and episodic word learning in dementia of the Alzheimer's type. *Brain and Language, 30*, 14-20.

Pache, M., Smeets, C. H. W., Gasio, P. F., Savaskan, E., Flammer, J., Wirz-Justice, A., et al. (2003). Colour vision deficiencies in Alzheimer's disease. *Age and Aging, 32* ,422-426.

Paivio, A., Clark, J. M., Digdon, N., & Bons, T. (1989). Referential processing: Reciprocity and correlates of naming and imaging. *Memory and Cognition, 17,* 163-174.

Panis, S., Vangeneugden, J., Op de Beeck, H. P., & Wagemans, J. (2008). The representation of subordinate shape similarity in human occipitotemporal cortex. *Journal of Vision, 8,* 1-15.

Pashler, H., & Harris, C. R. (2001). Spontaneous allocation of visual attention: dominant role of uniqueness. *Psychonomic Bulletin & Review, 8,* 747-752.

Pearson, R. C. A., Esiri, M. M., Hiorns, R. W., Wilcock, G. K., & Powell, T. P .S. (1985). Anatomical correlates of the distribution of the pathological changes in the neocortex in Alzheimer disease. *Proceedings of the National Academy of Sciences of the United States of America, 82*, 4531-4534.

Pechmann T, & Zerbst D. (2002). The activation of world class information during speech production. *Journal of Experimental Psychology: Learning, Memory and Cognition, 28*, 233-243.

Perani, D., Cappa, S.E., Bettinardi, V., Bressi, S., Gorno-Tempini, M., Matterrese, M & Fazio, F. (1995). Different neural systems for the recognition of animals and manmade tools. *Neuroreport, 6,* 1637-1641

Perani, D., Schnurt, T., Tettanmanti, M., Gorno-Tempini, M., Cappa, S.E., & Fazio, F. (1999). Word and picture matching: a PET study of semantic category effects. *Neuropsychologia*, *37*, 293-306.

Pérez, M. A., & Navalón, C. (2003). Normas espanõlas de 290 nuevos dibujos: Acuerdo en la denominación, concorancia de la imagen, familiaridad, complejidad visual y variabilidad de la imagen (Spanish norms for 290 new drawings: name agreement, image agreement, familiarity, visual complexity, and image variability). *Psicológia*, *24*, 215-241.

Perri, R., Carlesimo, G. A., Zannino, G. D., Mauri, M., Muolo, B., Pettenati, C., & Caltagirone, C., (2003). Intentional and automatic measures of specific-category effect in the semantic impairment of patients with Alzheimer's disease. *Neuropsychologia, 41(11),* 1509-1522.

Pietrini, V., Nertempi, P., Vaglia, A., Revello, M.G., Pinna, V. & Ferromilone, F. (1988) Recovery from herpes-simplex encephalitis – selective impairment of specific semantic categories with neuroradiological correlation. *Journal of Neurology Neurosurgery and Psychiatry, 51,* 1284-1293.

Poon, L. W., & Fozard, J. L. (1978). Speed of retrieval from long-term memory in relation to age, familiarity, and datedness of information. *Journals of Gerontology, 33,* 711-717.

Price, C. J., & Humphreys, G. W., (1989). The effects of surface detail on object categorization and naming. *Quarterly journal of Experimental Psychology A, Human Experimental Psychology, 41*, 797-827.

Rapp, B. C., Hillis, A. E., & Caramazza, A. (1993). The role of representations in cognitive theory – more on multiple semantics and the aagnosias. *Cognitive Neuropsychology, 10*, 235-249.

Ratcliffe, G., & Newcombe, F. (1982). Object recognition: Some deductions from the clinical evidence. In *Normality and Pathology in Cognitive Functions,* A. W. Ellis (Ed.), pp. 147-171. London: Academic Press, London.

Regan, D. (2000). *Human Perception of Objects: Early Visual Processing of Spatial Form Defined by Luminance, Color, Texture, Motion and Binocular Disparity.* Sunderland MA: Sinauer Associates.

Riddoch, M. J. (1984). *Neurological Impairments of Visual Perception.* Unpublished Ph.D. thesis. University of London.

Riddoch, M.J. and Humphreys, G.W. (1987a). Visual object processing in optic aphasia: a case of semantic access agnosia. *Cognitive Neuropsychology, 4,* 131-185.

Riddoch, M. J., & Humphreys, G. W. (1987b). A case of integrative visual agnosia. *Brain, 110,* 1431-1462.

Riddoch, M. J., & Humphreys, G. W. (2004). Object identification in simultanagnosia: When wholes are not the sum of their parts. *Cognitive Neuropsychology, 21*, 432-441.

Riddoch, M. J., Humphreys, G. W., Coltheart, M., & Funnell, E. (1988). Semantic system or systems? Neuropsychological evidence reexamined. *Cognitive Neuropsychology, 5,* 3-25.

Rizzo, M., Anderson, S. W., Dawson, J., & Nawrot, M. (2000). Vision and cognition in Alzheimer's disease. *Neuropsychologia*, *38*, 1157-1169.

Rogers, T. T., Ivanoiu, A., Patterson, K., & Hodges, J. R. (2006). Semantic memory in Alzheimer's disease and the frontotemporal dementias: A longitudinal study of 236 patients. *Neuropsychology,* **20**, 319–335.

Rogers, J., & Morrison, J. H. (1985). Quantitative morphology and regional and laminar distributions of senile plaques in Alzheimers-disease. *Journal of Neuroscience, 5,* 2801-2808.

Rosenberg, M. S., Adams, D. C., & Gurevitch, J. (2000). MetaWin: Statistical Software for Meta-analysis, Version 2.0. Sinauer Associates, Sunderland, MA.

Ross, T. P., Lichtenberg, P. A., & Christensen, B. K. (1995). Normative data on the Boston Naming Test for elderly adults in a demographically diverse medical sample. *The Clinical Neuropsychologist, 9,* 321–325.

Rossion, B., & Pourtois, G. (2004). Revisiting Snodgrass and Vanderwart's object pictorial set: the role of surface detail in basic-level object recognition. *Perception*, 33, 217-236.

Sacchett, C., & Humphreys, G. W. (1992). Calling a squirrel a squirrel but a canoe a wigwam: A category-specific deficit for artefactual objects and body parts. *Cognitive Neuropsychology, 9,* 73-86.

Salmon, D. P., Butters, N., & Chan, A. S. (1999). The deterioration of semantic memory in Alzheimer's disease. *Canadian Journal of Experimental Psychology, 53,* 108-116.

Samson, D., & Pillon, A. (2003). A case of impaired knowledge for fruit and vegetables. *Cognitive Neuropsychology*, *20(3-6),* 373-400.

Samson D, Pillon A & De Wilde V. (1998). Impaired knowledge of visual and non-visual attributes in a patient with a semantic impairment for living entities: A case of a true category-specific deficit. *Neurocase, 4,* 273-290.

Sartori, G., Gnoato, F., Mariani, I., Prioni, S., & Lombardi, L. (2006). Semantic relevance, domain specificity and the sensory/functional theory of category-specificity. *Neuropsychologia, 45*, 966-976.

Sartori, S., & Job, R. (1988). The oyster with four legs: A neuropsychological study on the interaction of visual and semantic information. *Cognitive Neuropsychology*, *5*, 105-132.

Sartori G, Job R, Miozzo M, Zago S & Marchiori G. (1993). Category-specific form-knowledge deficit in a patient with herpes-simplex virus encephalitis. *Journal of Clinical and Experimental Neuropsychology, 15,* 280-299.

Sartori, G., Miozzo, M., & Job, R. (1993). Category specific semantic impairments? Yes. *The Quarterly Journal of Experimental Psychology, 46A,* 489-504.

Schlotterer, G., Moscovitch, M., & Crapper-McLachlan, D. (1984). Visual processing deficits as assessed by spatial frequency contrast sensitivity and backward masking in normal ageing and Alzheimer's disease. *Brain, 107,* 309-325.

Schmitter-Edgecombe, M., Vesneski, M., & Jones, D. W. R. (2000). Aging and word-finding: A comparison of spontaneous and constrained naming tests. *Archives of Clinical Neuropsychology, 15,* 479–493.

Scholnick, E., Nicholas, L. E., Brookshire, R. H., Maclennan, D. L., Schumacher, J. G., & Porrazzo, S. A. (1989). Revised administration and scoring procedures for the Boston naming test and norms for non-brain-damaged adults. *Aphasiology, 3,* 569-580.

Scopus.com homepage. Available: www.scopus.com

Sergent, J. (1983). Role of the input in visual hemispheric asymmetries. *Psychological Bulletin, 93,* 481-512.

Shallice, T. (1988a). Specialization within the semantic system. *Cognitive Neuropsychology, 5*, 133-142.

Shallice, T. (1988b). *From Neuropsychology to Mental Structure*. Cambridge: CUP

Shelton, J . R., Fouch, E., & Caramazza, A. (1998). The selective sparing of body part knowledge: A case study. *Neurocase, 4,* 339-351.

Sheridan, J., & Humphreys, G. W. (1993). A verbal-semantic category-specific recognition impairment. *Cognitive Neuropsychology, 10,* 143-184.

Silveri, M. C., Cappa, A., Paolo, M., & Maria, P., (2002). Naming in patients with Alzheimer's disease: influence of age of acquisition and categorical effects. *Journal of Clinical and Experimental Neuropsychology, 24,* 755-764.

Silveri , M., Daniele, A., Giustolici, L., & Gainotti, G. (1991). Dissociation between knowledge of living and nonliving things in dementia of the Alzheimer's type. *Neurology, 41*, 545-546.

Silveri, M., & Gainotti, G. (1988). Interaction between vision and language in category-specific semantic impairment. *Cognitive Neuropsychology, 5,* 677-709.

Silveri, M., Gainotti, G., Perani, D., Cappelletti, J., Carbone, G., & Fazio, F. (1997). Naming deficit for non-living items: Neuropsychological and PET study. *Neuropsychologia, 35,* 359-367.

Silverman, I., Choi, J., Mackewn, A., Fisher, M., Moro, J., & Olshansky, E. (2000). Evolved mechanisms underlying wayfinding: Further studies on the hunter-gatherer theory of spatial sex differences. *Evolution and Human Behavior, 21,* 201-213.

Silverman, I., & Eals, M. (1992). Sex differences in spatial abilities: Evolutionary theory and data. In J.H.Barkow, L. Cosmides, & J. Tooby (Eds.), The Adapted Mind (pp.533-549). New York: Oxford.

Sirigu, A., Duhamel, J. R., & Poncet, M. (1991). The role of sensorimotor experience in object recognition. A case of multimodal agnosia. *Brain, 114,* 2555-2573.

Small, S.L., Hart, J., Nguyen, T., & Gordon, B. (1995). Distributed representations of semantic knowledge in the brain. *Brain, 118,* 441-453.

Snodgrass, J. G., & Vanderwart, M., (1980). A standardized set of 260 pictures: norms for name agreement, image agreement, familiarity and visual complexity. *Journal of Experimental Psychology, Human Learning and Memory, 6*, 174-215.

Snodgrass, J. G., & Yuditsky, T. (1996). Naming times for the Snodgrass and Vanderwart pictures. *Behaviour Research Methods, Instruments, & Computers, 28,* 516-536.

Stark, C. E. L., & Squire, L. R. (2000). fMRI activity in the medial temporal lobe during recognition memory as a function of study-test interval. *Hippocampus, 10,* 329-337.

Stark, L., Eggert, D., & Bowyer, K. W. (1988). Aspect graphs and non-linear optimization in 3-D object recognition. In *Second International Conference on Computer Vision* (pp.501-507). Coral Gables, FL: IEEE Computer Society Press.

Stewart, F., Parkin, A., & Hunkin, N, (1992). Naming impairments following recovery from herpes simplex encephalitis: Category-specific? *The Quarterly Journal of Experimental Psychology A, 44,* 261-284.

Tanaka, J. W., & Presnell, L. M., (1999). Colour diagnosticity in object recognition. *Perception and Psychophysics, 61*, 1140-1153.

Tanaka, J. W., Weiskopf, D., & Williams, P. (2001). The role of colour in high-level vision. *Trends in Cognitive Sciences, 5 (5),* 211-215.

Tarr, M. J. (1995). Rotating objects to recognize them: A case study on the role of viewpoint-dependency in the recognition of three-dimensional objects. *Psychonomic Bulletin & Review, 2,* 55-82.

Tarr, M. J., & Bülthoff. (1998). Image-based object recognition in man, monkey, and machine. *Cognition, 67,* 1-20.

Tarr, M. J., & Pinker, S. (1989). Mental rotation and orientation-dependence in shape recognition. *Cognitive Psychology, 21,* 233-282.

Tarr, M. J. & Vuong, Q. C. Visual object recognition. *In:* H. Pashler & S. Yantis, ed. *Steven's Handbook of Experimental Psychology, Vol 1: Sensation and Perception*. New York, NY: John Wiley & Sons, Inc, 2002, pp. 287-314.

Tarr, M. J., Williams, P., Hayward, W. G., & Gauthier, I. (1998). Three-dimensional object recognition is viewpoint dependent. *Nature Neuroscience, 1,* 275-277.

Taylor, R. N. (2006). *TestBed RT Generator Program Version 1.0.* [Computer Software]. University of Hertfordshire.

Thomas, R., & Forde, E. (2006). The role of local and global processing in the recognition of living and non-living things. *Neuropsychologia, 44,* 982-986.

Thompson-Schill, S.L., Aguire, G.K., D'exposito., M.D., & Farah, M.J. (1999). A neural basis for category and modality specificity of semantic knowledge. *Neuropsychologia, 37,* 671-676.

Tippett, L., Grossman, M., & Farah, M. (1996). The semantic memory impairments of Alzheimer's disease: Category-specific? *Cortex, 32,* 143-153.

Tippett, L. J., Meier, S. L., Blackwood, K., & Diaz-Asper. C. (2007). Category specific deficits in Alzheimer's disease: fact or artefact? *Cortex, 43,* 907-920.

Tombaugh, T. N., & Hubley, A. M. (1997). The 60-item Boston Naming Test: Norms for cognitively intact adults aged 25 to 88 years. *Journal of Clinical and Experimental Neuropsychology, 19,* 922–932.

Tranel, D., Logan, C. G., Frank, R. J., & Damasio, A. R. (1997). Explaining category-related effects in the retrieval of conceptual and lexical knowledge for concrete entities. *Neuropsychologia, 35,* 1329-1339.

Troscianko, T., & Harris, J. (1988). Phase discrimination in compound chromatic gratings. *Vision Research*, *28*, 1041-1049.

Tulving, E. (1972). Episodic and semantic memory. In Tulving, E. & Donaldson, W. (Eds.) *Organization of Memory*. New York: Academic Press.

Turnbull, O.H., & Laws, K.R. (2000) Loss of stored knowledge of object structure: Implications for "category-specific" deficits. *Cognitive Neuropsychology 17*, 365-389.

Tyler, L. K., & Moss, H. E. (1997). Functional properties of concepts: studies of normal and brain-damaged patients. *Cognitive Neuropsychology*, *14*(4), 511-547.

Tyler, L.K., Moss, H.E., Durrant-Peatfield, M.R. and Levy, J.P. (2000). Conceptual structure and the structure of concepts: a distributed account of category specific deficits. *Brain and Language*, *75,* 195-213.

Van Orden, G.C., Pennington, B. F., & Stone, G. O. (2001). What do Double Dissociations Prove? *Cognitive Science*, *25*, 111-172.

Van Petten, C., Senkfor, A. J., & Newberg, W. M., (2000). Memory for line drawings in locations: spatial source memory and event-related potentials. *Psychophysiology, 37,* 551-564.

Vannucci, M., Viggiano, M. P., & Argenti, F. (2001). Identification of spatially filtered stimuli as a function of the semantic category. *Cognitive Brain Research, 12*, 475-478.

Viggiano, M. P., Costantini, A., Vannucci, M., & Righi, S. (2004). Hemispheric asymmetry for spatially filtered stimuli belonging to different semantic categories. *Cognitive Brain Research, 20,* 519-524.

Viggiano, M. P., Righi, S., & Galli, G. (2006). Category-specific visual recognition as affected by aging and expertise. *Archives of Gerontology and Geriatrics, 42,* 329-338.

Viggiano, M. P., & Vannucci, M. (2002). Drawing and identifying objects in relation to semantic category and handedness. *Neuropsychologia*, *40*, 1482-1487.

Viggiano, M. P., Vannucci, M., & Righi, S. (2004). A new standardised set of ecological pictures for experimental and clinical research on visual object processing. *Cortex*, *40*, 491-509.

Vitkovitch, M., Humphreys, G. W., & Lloyd-Jones, T. J., (1993). On naming a giraffe a zebra: Picture naming errors across different object categories. *Journal of Experimental Psychology, Learning, Memory, and Cognition*, *19*, 243-259.

Vitkovitch, M., & Tyrell, L. (1995). Sources of disagreement in object naming. *Quarterly Journal of Experimental Psychology, Section A Human Experimental Psychology, 48*, 822-848.

Vogel, A., Gade, A., Stokholm, J., & Waldemar, G. (2005). Semantic memory impairment in the earliest phases of Alzheimer's disease. *Dementia and Geriatric Cognitive Disorders, 19,* 75–81.

Wagemans, J., De Winter, J., Op de Beeck, H., Ploeger, A., Beckers, T., & Vanroose, P. (2008). Identification of everyday objects on the basis of silhouette and outline versions. *Perception, 37,* 207-244.

Ward, J., & Parkin, A. J. (2000). Pathological false recognition and source memory deficits following frontal lobe damage. *Neurocase* ,6, 333-344.

Warrington, E. K. (1975). Selective impairment of semantic memory. *Quarterly journal of experimental psychology, 27,* 635-657.

Warrington, E. K., & McCarthy, R. A. (1983). Category specific access dysphasia. *Brain, 106,* 859-878.

Warrington, E. K., & McCarthy, R. A. (1987). Categories of knowledge: Further fractionations and an attempted integration. *Brain, 110,* 1273-1296.

Warrington, E. K., & McCarthy, R. A. (1994). Multiple meaning systems in the brain: A case for visual semantics. *Neuropsychologia, 32,* 1465-1473.

Warrington, E. K., & Shallice, T. (1979). Semantic access dyslexia. *Brain, 102,* 43-63.

Warrington, E. K., & Shallice, T. (1984). Category-specific semantic impairments. *Brain, 107,* 829-859.

Whatmough, C., Chertkow, H., Murtha, S., Templeman, D., Babins, L., & Kelner, N. (2003). The semantic category effect increases with worsening anomia in Alzheimer's type dementia. *Brain and Language, 84*, 134-147.

Wierzbiecka, A. (1985). Lexicography and conceptual analysis. Ann Arbor, MI: Karoma Publishers.

Wiggs, C. L., Weisberg, J., & Martin, A. (1999). Neural correlates of semantic and episodic memory retrieval. *Neuropsychologia, 37,* 103-118.

Wijk, H., Berg, S., Sivik, L., & Steen, B. (1999). Colour discrimination, colour naming and colour preferences among individuals with Alzheimer's disease. *International Journal of Geriatric Psychiatry, 14,* 1000-1005.

Williams, P., & Tanaka, J. W. (2000). Color effects on the recognition of distinctively shaped objects. Unpublished Manuscript, Oberlin College, Oberlin, OH 44074, USA.

Worrall, L. E., Yiu, E. M. L., Hickson, L. M. H., & Barnett, H. M. (1995). Normative data for the Boston Naming Test for Australian elderly. *Aphasiology, 9,* 541–551.

Wright, C. E., Drasdo, N., & Harding, G. F. A. (1987). Pathology of the optic nerve and visual association areas: Information given by the flash and pattern visual evoked potential, and the temporal and spatial contrast sensitivity function. *Brain, 110,* 107-120.

Wurm, L. H., Legge, G.E., Isenberg, L. M., & Luebker, A. (1993). Color improves object recognition in normal and low vision. *Journal of Experimental Psychology: Human Perception and Performance, 19,* 899-911.

Yamadori, A., & Albert, M. I. (1973). Word category aphasia. *Cortex, 9,* 112–125.

Yip, A. W., & Shina, P. (2002). Contribution of colour to face recognition. *Perception, 31,* 995-1003.

Young, A. W., & Ellis, H. D. (1989). Childhood Prosopagnosia. *Brain and Cognition, 9,* 16-47.

Zannino, G. D., Perri, R., Caltagirone, C., & Carlesimo, G. A. (2007). Category-specific naming deficit in Alzheimer's disease: The effect of a display by domain interaction. *Neuropsychologia, 45,* 1832-1839.

Zannino, G. D., Perri, R., Carlesimo, G. A., Pasqualetti, P., & Caltagirone, C. (2002). Category-specific impairment in patients with Alzheimer's disease as a function of disease severity: a cross sectional investigation. *Neuropsychologia, 40,* 2268-2279.

Zannino, G. D., Perri, R., Pasqualetti, P., Caltagirone, C., & Carlesimo, G. A. (2006). (Category-specific) semantic deficit in Alzheimer's patients: the role of semantic distance. *Neuropsychologia, 44,* 52-61.

Zeki, S. (1993). *A Vision of the Brain.* Oxford: Blackwell.