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Thesis

The Robot Club: Robots as agents to improve the social skills of young people on the autistic spectrum

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1. Abstract

To better understand the difficulties and strengths associated with both high and low functioning individuals with an autistic spectrum disorder (ASD), the hyper-systemising theory has been proposed by Baron-Cohen and colleagues. It explains the social and communication difficulties in autism and Asperger syndrome (AS) by reference to delays and deficits in empathy, whilst explaining the areas of strength by reference to intact or even superior skill in systemising (Baron-Cohen, 2002). The evidence for hyper-systemising alongside hypo-empathising in autism, suggests a corresponding desire to systemise the social world. Based on this theory, the use of technology in supporting the development of social and communication skills in children with an ASD is discussed. Technology and computers rely on strict, predictable systems made up of sets of rules that can be programmed, determined and understood. Use of such technology to assist in the development of social skills in an individual with an ASD utilises an existing area of strength and engages a person in an often existing area of interest and/or obsession.

This thesis describes an exploratory study using non-humanoid robots with a group of young people with either high-functioning autism (HFA) or AS, which aimed to use robots as a focus of shared attention in a more naturally occurring and systemisable environment; thus promoting more implicit learning of social skills for this clinical group. Ten children attended the 'robot club' for eight sessions enabling a design using a series of single case studies pooled together for multiple and individual base line comparisons. The results indicate improvements as rated by parents and the young people themselves (although not by teachers), with some evidence of statistical and clinically significant changes, for example, in communication skills specifically and with general difficulties associated with autism. The results were found to be affected by total number of sessions attended, but not by age or academic functioning. Possible implications of the findings are presented in line with theory and for clinical practise. Limitations of the study are discussed and suggestions for future research made.

2. Introduction

Autism is a set of neurodevelopmental conditions characterized by social interaction and communication difficulties, as well as unusually narrow, repetitive interests (American Psychiatric Association, 1994). Autistic spectrum disorders (ASDs) comprise of at least four subgroups: high-, medium-, and low-functioning autism (Kanner 1943) and Asperger syndrome (AS) (Asperger 1991; Frith 1991) (El Kaliouby, Picard, Baron-Cohen, 2006); with all four subgroups sharing these core diagnostic features. In addition, individuals with AS tend to have average or above average intelligence as measured by an intelligence quotient (IQ) and no significant language delay. In the other three autism subgroups there is invariably some degree of language delay, with the level of functioning being indexed by overall IQ (El Kaliouby *et al*, 2006).

Autism remains a behaviourally specified condition, the diagnosis dependent on interviews and/or direct observations (LeCouteur, Rutter & Lord, 1989; Lord, Risi, Lambrecht, Cook Jr., Leventhal, Dilavore, Pickles & Rutter, 2000; Lord, Rutter & LeCouteur, 1994; Lord, Rutter, Goode, Heemsbergen, Jordan, Mawhood & Schopler, 1989) and relies on the clinician's judgment about the individual's ability to engage in social interactions, process social information and deal with social anxiety (El Kaliouby *et al*, 2006) across multiple contexts, as well as necessitating a detailed developmental history. Interventions have largely been behavioural and most often aimed at addressing these social interaction and communication difficulties.

2.1 Psychological theories for ASDs

Autism is a disorder that affects many cognitive functions; however, it does not imply a global information processing deficiency (Scheuffgen, Happé, Anderson, & Frith, 2000). While the hallmark of the disorder is a failure of social communication, this does not imply a global lack of social ability. Rather, autism appears to be caused by one or more specific, i.e., circumscribed, cognitive deficits (Frith, 2001). Arguably the most relevant of these deficits in the origin of autism is a subtle but devastating deficit in human social insight (Frith, 2001).

2.1.1 Theory of mind

Early research into understanding this deficit focused on the theory that children with an ASD are delayed in developing a *theory of mind* (ToM), i.e., the ability to put oneself into someone else's shoes and to imagine their thoughts and feelings (see Baron-Cohen, 1995; Baron-Cohen, Leslie & Frith, 1985). When we mindread or mentalise, we not only make sense of another person's behaviour, but are able to also imagine a whole set of mental states and use these to predict what they might do next. The *mindblindness theory* proposes that children with autism and AS are delayed in developing a ToM, leaving them with degrees of mindblindness (Baron-Cohen, 2008a). As a consequence, they are unable to explain or predict others' behaviour through presumed thoughts and feelings, therefore finding 'other people's behaviour confusing and unpredictable, even frightening' (Baron-Cohen, 2008a). Experimental neuropsychological evidence suggests that people on the autism spectrum have an impaired ability to empathise or 'mentalise' (Frith, 2004), and this is thought to underlie the difficulties that they have in responding flexibly and fluently in social interaction (Baron-Cohen, 1988).

However, able individuals with ASDs can with time and practice achieve some awareness of mental states by compensatory learning (Frith, 2001). In normally developing children, the mentalising mechanism allows fast learning of socially and culturally transmitted knowledge, including the meaning of words. Since children with ASDs can be very intelligent and can learn by other means (for example, rote learning or above average understanding of maths and science), the underlying brain abnormality must be sufficiently specific and circumscribed so as not to compromise general information processing ability (Frith, 2001).

Evidence for this theory has been presented from developmental psychology by comparing those with an ASD to typically developing infants and young children. The mindblindness theory predicts that the milestones of the normal development of mentalising should be absent at the appropriate age in young children with autism (Frith, 2001). At each developmental milestone, children on the autistic spectrum have been found to show reduced or delayed abilities in the development of the capacity to mindread. For example, less use of pretend play at twenty-four months old, alongside less preference for speech over non-speech and less use of joint attention in early

infancy (see Baron-Cohen, 2008a). These developmental delays have been reported consistently across early development and levels of functioning.

Limited evidence from neuro-imaging scans has also been presented, however only a few studies have investigated the neuro-physiological substrate of mentalising. This is partly due to the difficulties in designing suitable mentalising tasks with closely matched control tasks (i.e., tasks that differ only in the requirement to mentalise) (Frith, 2001). Existing studies of normal volunteers have used contrasting conditions with stories (Fletcher, Happe´, Frith, Baker, Dolan, Frackowiak & Frith, 1995; Gallagher, Happe´, Bruswick, Fletcher, Frith & Frith, 2000; Vogeley, Bussfeld, Newen, Herrmann, Happe´, Falkai, Maier, Shah, Fink & Zilles, 2001), cartoons (Gallagher *et al.* 2000), picture sequences (Brunet, Sarfate, Hardy-Bayle & Decety, 2000), and animated geometric shapes (Castelli, Happe´, Frith & Frith, 2000). In all these studies, a network of brain regions was identified that was consistently active during mentalising over and above the specific demands of the respective tasks (Frith, 2001) specifically, the medial prefrontal cortex, the temporal-parietal junction at the top of the superior temporal gyrus and the temporal poles adjacent to the amygdala. However, few studies to date have specifically studied individuals with an ASD on mentalising tasks. Functional brain imaging of mentalising in individuals with an ASD suggests less or no activation in the above mentioned expected brain regions, with some suggestion of higher activation in other regions, e.g., peak activation in a more ventral region of the frontal cortex (see Baron-Cohen, Tager-Flusberg & Cohen, 1999; Happe´, Ehlers, Fletcher, Frith, Johannsson, Gilberg, Dolan, Frackowiak & Frith, 1996). However, the presented data is minimal.

A strength of the mindblindness theory is that it 'makes sense of the core social and communication impairments of individuals with autism' (Frith, 2001) and AS (Baron-Cohen, 2008a). In addition, 'it is universal in applying to all individuals on the autistic spectrum' (Baron-Cohen, 2008a) regardless of intellectual ability or level of functioning. However, this remains a controversial theory as it 'cannot account for the non-social features of autism (Baron-Cohen, 2008a), such as obsessional behaviours. Secondly, whilst mindreading is one component of empathy, true empathy also requires an emotional response to another person's state of mind (Davis, 1994); many people on the autistic spectrum also report that they are puzzled by how to respond to another person's emotions (Grandin, 1996). A final limitation is that a range of other clinical conditions also

show forms of mindblindness, such as patients with schizophrenia (Corcoran & Frith, 1997) or narcissistic and borderline personality disorders (Fonagy, 1989), or children with conduct disorder (Dodge, 1993) or those who are deaf (Marschark, Green, Hindmarsh & Walker, 2000), so this may not be specific to autism and AS (Baron-Cohen, 2008a).

2.1.2 Weak central coherence

Frith and Happé (1994) proposed the concept of central coherence as an addition to the ToM approach in understanding the cognitive style of individuals with autism. The *weak central coherence* hypothesis proposes that individuals on the spectrum have a preference for local detail rather than global information, the latter normally taking precedence in the typically developing child (see Frith, 1989). This theory stems from a study by Witkin, Dyk, Faterson, Goodenough, & Karp (1962), and has received some empirical support since (e.g., Jolliffe & Baron-Cohen, 1997; Shah & Frith, 1993; Jolliffe & Baron-Cohen, 2000, 2001; Plaisted, O'Riordan, & Baron-Cohen, 1998a, 1998b). It suggests that children on the autistic spectrum may find it difficult to integrate information, adopting a local verses global processing style by attending to each detail independently and thus struggling to 'see the wood for the trees'. This has also been linked to difficulties in being creative in producing original ideas, sometimes referred to as a deficit in creativity (e.g., Craig & Baron-Cohen, 1999; Craig, Baron-Cohen & Scott, 2001).

This theory intended to help explain aspects of autistic functioning that are not well explained by ToM deficits; namely, the tendency to focus on local features of the environment. It would predict that people with an ASD would never come to understand a whole system. However, a whole system is not only made up of local, proximate rules ('A causes B', where A and B are adjacent components) but also of distant rules ('B causes Z', where Z is distal); furthermore, a system is made not only of local elements (e.g., musical notes) but also of relationships between those elements (such as intervals between notes) (Baron-Cohen, 2002). Studies of autistic 'savants' show that there is often a good implicit understanding of the rules of the system (be it maths, drawing, syntax, calendars) and of relational patterns within the systems (Hermelin, 2001). Many individuals with autism will also focus deeply on a given subject, which can lead to original thought (El Kaliouby *et al.*, 2006).

2.1.3 Hyper-systemising

The *hyper-systemising* or *empathising - systemising theory* was developed out of a desire to revise the above theories to better explain the non-social areas of strength (good attention to detail, deep narrow interest and islets of ability) and to broaden the concept of ToM to include an emotional reactivity dimension. This theory explains the social and communication difficulties in autism and AS by reference to delays and deficits in empathy, whilst explaining the areas of strength by reference to intact or even superior skill in systemising (Baron-Cohen, 2002).

'Empathising' is described as the drive to identify another person's emotions and thoughts, and to respond to these with an appropriate emotion. Empathising allows you to predict a person's behaviour, and to care about how others feel (Baron-Cohen, 2002). 'Systemising' is the drive to analyse the variables in a system, to derive the underlying rules that govern the behaviour of a system and also refers to the drive to construct systems, thus allowing you to predict the behaviour of a system, and to control it (Baron-Cohen, 2002).

The *empathising - systemising theory* of sex differences suggests five brain types (or cognitive styles) derived from two orthogonal dimensions, empathising and systemising (see Baron-Cohen, 2002). The first is characterised by systemising being more developed than empathising, a profile more common in males (S>E or Type S). The second by empathising being more developed that systemising, a profile found to be more common in females (E>S or Type E). The third suggests a balanced brain whereby empathising and systemising are equally developed (S=E or Type B). The remaining two types are characterised by extreme forms of the 'male' and 'female' brains (see Baron-Cohen, 2002; El Kaliouby *et al.*, 2006). Autism appears to correspond to an extreme of the male brain (S>>E or Extreme Type S), with systemizing being intact or above average, alongside empathising being impaired (Baron-Cohen 2006).

There is considerable evidence for empathy impairments in ASDs (Baron-Cohen, 1995) not just using child-level tests of false-belief understanding (Baron-Cohen, Leslie, & Frith, 1985), but also more subtle tests of complex emotion recognition (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001), recognition of faux pas (Baron Cohen, O'Riordan, Jones, Stone, & Plaisted, 1999), and spontaneous ascription of intentional

states (Castelli, *et al.,* 2000). In this sense, people with an ASD can be said to show hypo-empathising (Baron-Cohen, 2008a). This is apparent using neuroimaging during empathy tasks, where there is reduced blood flow in key brain regions such as the amygdala and medial prefrontal cortex (Baron-Cohen, Ring, Wheelwright, Bullmore, Brammer, Simmons, *et al.*, 1999; Courchesne, 2002; C. Frith & Frith, 1999; Happe´ *et al.*, 1996).

Alongside hypo-empathising, evidence for hyper-systemising in autism is also discussed in the literature. People with an ASD have an increased rate of savant skills, often in lawful systems such as calendars, calculation, or train timetables (Hermelin, 2002). They typically score higher than average on the systemising quotient (Baron-Cohen, Richler, Bisarya, Gurunathan & Wheelwright, 2003), on tests of folk physics (Baron-Cohen, Wheelwright, Scahill, Lawson, & Spong, 2001; Jolliffe & Baron-Cohen, 1997; Lawson, Baron-Cohen & Wheelwright, 2004; Shah & Frith, 1983) and on tests of attention to detail (O'Riordan, Plaisted, Driver, & Baron-Cohen, 2001; Plaisted, O'Riordan, & Baron-Cohen, 1998). People with AS can achieve high levels in domains such as mathematics, physics, or computer science (Baron-Cohen, Wheelwright, Stone, & Rutherford, 1999) and may have an "exact mind" when it comes to art (Myers, Baron-Cohen, & Wheelwright, 2004). On the picture-sequencing task, they perform above average on sequences that contain temporal or physical-causal (i.e., systematic) information (Baron-Cohen, Leslie, & Frith, 1986). Their obsessions cluster in the domain of systems, such as watching electric fans go round (Baron-Cohen & Wheelwright, 1999) and given a set of coloured counters, they show extreme "pattern imposition" (Frith, 1970). In short, they hyper-systemise (Baron-Cohen, 2008b).

The strength of the *hyper-systemising* theory is that it is a two-factor theory that can explain the cluster of both the social and non-social features in ASDs (Baron-Cohen, 2008a). Below-average empathy is a simple way to explain the social-communication difficulties, whilst above average systemising is a way of explaining the narrow interests, repetitive behaviour, and resistance to change/need for sameness (Baron-Cohen, 2008a). This two-factor approach is also universal in applying to all individuals on the autistic spectrum regardless of level of function, as it can explain both the behaviours typical in classic autism and those present in high-functioning autism (HFA) and AS.

In contrast to the weak central coherence theory, the *hyper-systemising* theory suggests that people with autism or AS start their cognitive processing by focussing in on the most local details, as an attempted search for whether these might be 'variables' in a systemisable domain. This focus on local processing might appear to arise from a deficit in global processing, but from the perspective of systemising, local detail is simply the best (possibly the only) place to start (Baron-Cohen, 2002). Moreover, if one is ever to 'crack' a system, it is best to over-attend to a small part of the system, and isolate and understand the laws governing a small number of relevant variables, before moving onto the next part of the system. This might appear as a narrow, obsessive preoccupation with the details of a highly specific phenomenon (e.g. spinning the wheels on a toy car) (Baron-Cohen, 2002).

One of the interesting aspects of this theory is that the brain types are continuous, blending seamlessly with normality; that is, we are all situated somewhere on the same continuum, and one's position on the continuum reflects a different cognitive style and inclination toward systemizing or empathising (El Kaliouby *et al.*, 2006). An important implication of this dimensional model is that the line between ability and disability is blurred (El Kaliouby *et al.*, 2006). This may be positive for the de-stigmatisation of ASD as it implies that it is not categorically different from 'neuro-typical' development and is thus not essentially 'different' or implicitly pathological.

Evidence for systemising being part of a broader autism phenotype includes the findings that fathers (and even grandfathers) of children with an ASD are twice as likely to work in the occupation of engineering (a clear example of a systemising occupation) (Baron-Cohen, Wheelwright, Scott, Bolton & Goodyer, 1997). Students in the natural sciences (engineering, mathematics, physics) also have a higher number of relatives with autism (Baron-Cohen, Bolton, Wheelwright, Short, Mead, Smith, *et al.* 1998). Both mothers and fathers of children with AS have been found to be strong in systemizing on the Embedded Figures Test (Baron-Cohen & Hammer, 1997). Finally, there is some evidence that above average systemisers have more autistic traits (Baron-Cohen, 2008b). These findings suggest a link between systemising talent and autistic traits, the link being likely to be genetic (Baron-Cohen, 2008b), although social rearing factors may also contribute.

2.2 Why improve social skills

Individuals with ASDs display marked impairments in the use of multiple non-verbal behaviours, such as eye-to-eye gaze, facial expressions, body postures and gestures to regulate social interaction (American Psychiatric Association, 1994). In addition, these individuals often fail to monitor the effects of their conversations or behaviours on other people (Barry, Klinger, Lee, Palardy, Gilmore & Bodin, 2003). For example, they frequently monopolise conversations or walk away while others are trying to interact with them (Baron-Cohen & Bolton, 1993); all of which suggests impairment in the development of reciprocal social interaction and communication skills.

Frequently identified problem areas include impairments in social pragmatics (e.g., turn-taking in conversation and the ability to take the listener's perspective), poor speech prosody (e.g., monotone, unlike typically rising and falling of voice pitch and inflection that aids verbal communication), a tendency to dwell on certain topics, difficulty understanding and expressing emotions, and difficulty interpreting non-literal language such as sarcasm and metaphor (Krasny, Williams, Provencal, & Ozonoff, 2003; Kerbel & Grunwell, 1998; Shaked & Yirmiya, 2003; Tager-Flusberg, 2003). Socialisation deficits are a major source of impairment regardless of cognitive or language ability (Carter, Davis, Klin, & Volkmar, 2005) and social skill deficits do not remit with development (White, Keonig & Scahill, 2007). Indeed, impairment and distress may increase as children approach and enter adolescence because the social milieu becomes more complex and the child becomes more aware of their social disability (Schopler & Mesibov, 1983; Tantam, 2003).

The diagnostic criteria also specify that the social and communication difficulties must cause impairment in social, occupational or other important areas of functioning (see DSM-IV, American Psychiatric Association, 1994). This therefore stresses the impact that these difficulties can have on other aspects of an individual's life. Therefore, on a practical level, supporting development of social skills may lead to both long-term and short-term success, enabling an individual to manoeuvre successfully within our social world. Competent social interactions are clearly necessary for adjustment and successful functioning in society (Hansen, Nangle & Meyer, 1998). For example, increased social skills and understanding, can lead to more independent living and improved job competence.

2.3 High-functioning autism and Asperger syndrome

Recently, more attention has been focused on the study of the unique social-emotional characteristics of children with an ASD who have average or above-average intelligence (Bauminger, 2002). This subgroup of children can engage in a higher level of social relationships and more complex emotions compared with low-functioning children with autism, probably due to the fact that the former at least partially compensate for their social deficit by utilizing their relatively high cognitive abilities (Hermelin & O'Connor, 1985; Kasari, Chamberlain, & Bauminger, 2001; Sigman & Ruskin, 1999). Average or above average IQ and/or verbal ability can therefore mask the presence of a developmental disorder such as AS or HFA, which may result in higher expectations of the individual by those around them or in delayed diagnosis.

In HFA or AS where language development is not delayed and cognitive skills are in the average or superior range, the diagnosis is often not made until school age, or even later (Gillberg, Nordin & Ehlers, 1996). Indeed, the average age of diagnosis for children with AS has been shown to be 11 years (Howlin & Moore, 1997; Howlin & Asgharian, 1999). Williams, Scott, Stott, Allison, Bolton, Baron-Cohen & Brayne (2005) comment that AS is identified "too late" and that it should be possible to screen AS in children in primary school (i.e., aged 5-11 years) and monitor from then onwards. More recently, Baron-Cohen estimated the average age of diagnosis as 6 years (Hopkins, 2005), possibly due to improved awareness and/or better diagnostic practice.

Recent research identified difficulties in social initiation and in social-emotional understanding as the major problems of individuals with HFA or AS, rather than social insensitivity or social disinterest (Bacon, Fein, Morris, Waterhouse & Allen, 1998; Sigman & Ruskin, 1999), i.e., many are socially motivated but lack the necessary skills for appropriate performance. These children are caught in a vicious circle of social isolation (Bauminger, 2002). On the one hand, they have a desire to be socially involved with their peers and express loneliness and depression in the absence of such relationships. On the other hand, they have poor friendships and do not know how to adequately interact with their peers due to limited social and emotional understanding and experiences (Bauminger & Kasari, 2000; Hobson, 1993; Wing, 1992).

Although children with HFA or AS display impairments in social skills, they appear to have a desire for social involvement and recognize when it is lacking (Barry *et al.*, 2003). Specifically, studies show that children with autism may experience perceptions of poor social support and loneliness leading to feelings of isolation and low self-esteem. For example, Bauminger and Kasari (2000) found that high-functioning children with autism, when compared to typical peers, reported significantly greater feelings of loneliness. Barnhill (2001) found that children with autism were more likely to attribute social failure to a lack in their own abilities than typically developing peers. These results are important in light of the findings that adolescents and adults with HFA, who have insight into their serious impairments, are susceptible to high rates of co-morbid depression (American Psychiatric Association, 1994; Barnhill, 2001; Ghaziuddin, Weidmer-Mikhail & Ghaziuddin, 1998). This has led to the recent attention to interventions designed specifically for this group of individuals, aimed at improving their social skills, and lowering their feelings and experiences of isolation and loneliness, also adapting treatments to manage emotional difficulties (e.g., Wood, Drahota, Sze, Har, Chiu & Langer, 2009).

However, the question of whether AS and HFA should be considered as the same or different conditions has been a source of debate and controversy over recent years (Howlin, 2003), which is why social skills training is often aimed at groups containing individuals with either diagnosis. The issue of whether they are distinct disabilities or different names for the same condition (see Klin, Volkmar, & Sparrow, 2000; Schopler, 1998; Schopler, Mesibov, & Kunce, 1998; Wing, 1998), can make it difficult for clinicians looking to make a diagnosis and can influence the type of support an individual has access to. Research has suggested that differences between these two subgroups are more apparent in childhood, where 'parents do report certain differences between the groups when they are younger' (Howlin, 2003), such as development of language and the age parents first notice abnormalities in overall development. However, the research suggests that the differences between the two groups seem to become less evident as they grow older (Gilchrist, Green, Cox, Rutter & Le Couteur, 2001; Ozonoff, South, & Miller, 2000; Szatmari, Archer, Fisman, Streiner, & Wilson, 1995); although it is important to interpret this with caution, due to the revised diagnostic criteria used in some studies for recruiting participants with AS. Despite this, there is little to support the view that individuals with a diagnosis of AS should be deprived of the support and services that

are available for those with a diagnosis of autism, or that educational and management programs should differ in any way (Howlin, 2003).

2.4 Research into social skills interventions

A variety of social interventions have been designed to try and improve the social and communication skills of young people with HFA and AS (see Rogers, 2000 for a review). The use of social skills groups seems to be becoming increasingly popular, with an increase in the number of 'children with autism being referred to outpatient mental health clinics for social skills interventions' (Barry *et al*, 2003). Although social skills groups in these settings are common, little research has been conducted to determine the efficacy of such treatments for children with HFA and AS (Rogers, 2000). The use of groups to teach social skills therefore remains controversial, as the reported benefits of attendance often seem to be regarded as limited by researchers.

2.4.1 School-based social skills groups

There is a large literature on school-based social skills interventions for children with autism and interventions involving peer training (Barry *et al*, 2003). However, it appears that the majority of research has been carried out with younger participants from pre-school age through the early school years, utilising play and peer modelling to increase both initiations and responses during social interactions. This body of research also looks specifically at teaching social skills to children with autism, rather than those with HFA or AS.

The majority of these studies have focussed on improving a broad range of skills such as initiating, responding, greeting others, conversing on a variety of topics, giving and accepting compliments, and sharing (e.g., Kamps, Leonard, Vernon, Dugan & Delquadi, 1992; Matson, Fee, Coe & Smith, 1991), and have reported marked improvements in positive social interaction (i.e., greetings, asking to see a toy, showing a toy and initiating play), whereas inappropriate behaviours (i.e., tantrums, aggression and grabbing toys) decreased (see Matson *et al*, 1991). Some studies have focussed on teaching a few specific social skills (e.g., eye contact and voice quality; play within the context of the child's obsessive interests; Baker, Koegel & Koegel, 1998) and have demonstrated improvements in the specific skills taught (Barry *et al*, 2003).

One advantage of offering school-based social skills group training is the availability of the children to attend sessions multiple days per week for short periods of time. The school setting is amenable to teaching skills five times per week or even more, i.e., for shorter time periods and multiple times per day (Barry *et al*, 2003).

The school setting also allows for the inclusion of typically developing peers in the teaching of social skills to children with autism. The use of peer education and peer training to support social skills training is present in the literature surrounding school-based interventions. The aim of these studies seems to have been to increase the number of social interactions between typically developing peers and children with autism. This would be achieved through educating and training typical peers to encourage children with autism to engage in social exchanges (Goldstein, Kaczmarek, Pennington & Shafer, 1992; Laushey & Heflin, 2000; Sainato, Goldstein & Strain, 1992). This may perhaps be based on social learning theory whereby a child with autism may be able to mimic the social interactions displayed by their peers and learn through imitation. Also, by increasing the number of social interactions, this may serve to decrease feelings of loneliness and isolation. However, it is not clear whether this is the case, as the research focuses on very young children with autism, rather than older children or adolescents with HFA or AS, and discusses mainly the number of social interactions observed, rather than their quality. However, these peer-mediated approaches have been shown to increase the number of social interactions between children with disabilities, including autism, and typical peers (Goldstein *et al*, 1992; Kamps, Kravits, Lopez, Kemmerer, Potucek & Harrell, 1998; McGee, Almeida, Sulzer-Azaroff & Feldman, 1992).

It is however interesting to consider in these studies whether the children with autism were able to maintain the increased levels of social interaction, and whether they were initiating these interactions or had purely learnt how to respond. The majority of studies find evidence that peer education and training leads to a larger increase in social initiations by typically developing children rather than by the children with autism (Goldstein *et al*, 1992; Haring, Breen, Pitts-Conway, Lee and Gaylord-Ross, 1987, Sainato *et al*, 1992).

With regards to the benefits reported, it appears that these approaches most often lead to temporary increases in social interactions by typical peers and increased responsiveness from children with autism. Unprompted interactions tend to decrease because of a lack of social competence on the part of the children with autism (Oke & Schreibman, 1990). It could also be possible that if typically developing peers are initialising more interactions, that this perhaps leads to children with an ASD becoming more passive in that environment. With a few exceptions (see Laushey and Heflin, 2000), these social interactions have not been found to generalise to other settings with untrained peers (Barry *et al*, 2003). However, research indicates that a combination of teaching social skills to children with autism, and peer education and reinforcement for typically developing peers, may be advantageous in increasing the duration and frequency of overall social interactions (Gonzalez-Lopez & Kamps, 1997).

The different methodologies adopted to measure the impact of these school-based interventions means a lack of a consistent or potentially gold-standard approach that may maximise generalisations. The number of children with autism differs across studies, with some researchers providing evidence from individual case studies, through to more large-scale sample sizes. The majority of studies focus on very young children and measure the number of social interactions before during and after training. Some researchers combine peer training with social skills training for the child with autism, whereas others evaluate one form of intervention.

The number of trained peers has been shown to affect the level of skill generalisation. Increasing the number of typically trained peers has been found to improve generalisability to non-trained peers. The use of artificial versus natural settings for the trained peers to initiate interactions with the children with autism has also been shown to affect generalisation, with more naturalistic settings supporting generalisability. However this has been harder to implement, as it requires a lot of training for teachers. The use of adult versus peer partners to practice the initiation skills has also been shown to affect the generalising of skills and the longevity of the increased number of interactions. Peers generated better responses than adults, with same age peers producing the best results. When adults were used, the children with autism did not generally transfer this to interaction with peers without specific training. Overall, social engagement appears to be a pivotal response, a skill that leads directly to increased attainment of other important

skills without the need for direct training/teaching (Rogers, 2000), which suggests that fostering social engagement is perhaps central.

Based on the methodologies adopted and the perceived outcomes of these school-based social skills groups, it appears that the aim of these groups is to teach or tutor these children as opposed to providing group therapy. The high use of typically developing peers also suggests that the group work is aimed at teaching/tutoring new skills, with little time spent on developing, for example, the children's understanding of their difficulties.

2.4.2 *Outpatient social skills groups*

Social skills training in outpatient clinics, differs somewhat from school-based interventions. There is less focus on the use of typically developing peers, and more focus around developing self-management strategies. In fact, typical peers do not seem to be included in the teaching and practising of social skills through social skills groups at all. This may be due to the average age of those attending social skills groups (namely adolescents), the nature of the social and communication difficulties that those with HFA and AS have, as well as the logistics of getting typically developing peers into an outpatient setting. The level of insight that these young people can have into their difficulties might make it particularly embarrassing for them to have typically developing peers present and the fact that the group is run from an outpatient clinic requires all group members to be referred. A typically developing peer would therefore not, under these circumstances, be referred to the group. The structure and frequency of the group meetings are also different; due to the nature of outpatient mental health clinics, social skills groups typically meet for one long session a week, for a number of weeks.

In comparison to school-based social skills interventions, there has been limited research conducted on outpatient social skills groups. Yet this form of intervention is better known, better packaged, easier to administer, and more available to the general public than those with a more firmly established empirical base (Rogers, 2000), such as peer-mediated approaches. Despite this low level of empirical evidence, social skills groups are quite common in this setting. Several centres have developed social skills interventions to address the needs of adolescents with ASDs, but few have reported on their efforts (Tse, Strulovitch, Tagalakis, Meng & Fombonne, 2007).

Researchers have used a variety of baseline assessment measures in order to measure the level of skill present before the social skills groups begin. The tests administered in each study depend on the skills to be taught, and the expectations of the study; for example, variously measuring general and specific social skills, non-verbal skills and emotional intelligence. These tests were then re-administered upon completion of the group. The fact that different tests have been used makes it harder to make direct comparisons between studies. Other measures are undertaken via observations of skills; as well as parent, teacher and/or self-report. However, this also remains inconsistent across the research. For those studies that include observation, the use of multiple researchers allows for inter-observer agreement to be rated. Limitations across the available research are apparent with regards to small sample sizes, and gender distribution of the adolescents included in the studies; in fact few studies have included the use of control groups to provide comparison data.

In terms of what is actually being measured, again individual studies differ. More recent studies seem to be focusing on specific social behaviours rather than general social skills. In combination, some studies are also looking for evidence of general social cognitive capacity.

With regards to the underlying psychological models being used to teach the desired social behaviours and skills within the group setting, the use of cognitive-behavioural therapy (CBT) appears in the literature, alongside the use of solution focused questions to promote problem solving skills and the generation of ideas. However, not all studies specify the models used to design the content of the group sessions, and different teaching strategies make it difficult to make direct comparisons of data across studies.

Several studies have demonstrated that young people with HFA and AS are able to utilise their relatively high cognitive abilities to acquire a better intellectual understanding of the social world (e.g., Kasari, Chamberlain & Bauminger, 2001; Capps, Yirmiya & Sigman, 1992, Hermelin & O'Connor, 1985; Sigman & Ruskin, 1999; Yirmiya, Sigman, Lasari & Mundy, 1992). Evidence presented regarding the tests administered as a baseline of skills and then again upon completion of the social skills groups shows a trend of improvement in the specific skills taught but not in other, or broader skills that were not directly targeted. However, these trends are not always found to be significantly

different. Across the studies and different situations, however, basic greeting skills seem to show consistent significant improvement.

Despite the often low levels of statistical significant differences noted between the pre and post measures, the researchers comment on many qualitative improvements. For example Bauminger (2002) noted improvements in the nature of solutions generated to social problems, even if no increased number of solutions were generated. There is an overall sense in the literature that the young people who attended the group showed an increase in their self-confidence and self-esteem as reported by parents, the young people themselves, and through observation. They all seemingly enjoyed attending the group and were keen to continue to attend each session. Friendships developed between the group members, and these social relationships were generally maintained (Barnhill, Cook, Tebbenkamp & Myles, 2002).

Importantly, the studies also present evidence relating to whether the young people who attended the groups were able to generalise the skills learnt to settings outside of the group. Some studies measured this transfer of skills through observation in a natural setting, others utilised parent and teacher reports post completion of the social skills group. Generalisation was generally limited to the specific skills taught. However, although the researchers report gains in participants' self-confidence and in the acquisition of some concrete social skills, feedback from parents suggests that the skills learnt did not fully generalise to the home, school or community (Barnhill *et al*, 2002) for many of the skills targeted. Difficulties were noted in transferring the skills leant from a clinic setting to a natural setting. Results differ across studies with high or low maintenance of specific social skills.

Based on the methodologies adopted and the perceived outcomes of these outpatient social skills groups, there appears to be a mixture of teaching/tutoring as well as therapeutic group work. This is particularly evident in the expression of qualitative improvements and the increase in the individual's self-esteem and self-confidence. The use of recognised therapies, i.e., CBT, to deliver the social skills training also suggests that the aims of the group were partially therapeutic in nature. Despite this, little mention is made of clinical significance verses statistical significance.

Although this is anecdotal evidence, from my own experiences of co-facilitating two, ten-week, social skills groups for adolescents with HFA and AS between the ages of 12-17 years, I have witnessed a large number of changes within and between the group members across the weekly sessions. As the group progresses through the sessions, the members develop a sense of trust in each other and show evidence of group cohesiveness, as suggested by the literature on group work with adolescents. Individual changes noted include initiating social interactions, greetings, improved eye contact, a greater understanding of their own difficulties and a willingness to share and discuss their own experiences.

The group members have often formed friendships outside of the group, by exchanging e-mail addresses and using internet messaging programs such as *msn* to keep in touch. The group members show a willingness to continue attending the sessions, missing very few sessions, other than for illness. This making, and maintaining, of friendships outside of the group, and keenness to attend, is also consistent with current research. The adolescents also reported benefits of attending the group to include making friends, meeting other people who have the same difficulties as them and having people to talk to about their difficulties. They also state that they would recommend the group to another person if they thought they had similar difficulties. Unfortunately, no empirical data has yet been collected with regards to the generalising of these skills to social situations outside of the group setting.

Interestingly, the adolescents often needed to attend the group for more than one set of sessions before they felt confident that they had got all they could get out of it. This allowed them to continue to practice the skills learnt, as well as bring their past experiences to help the new members. This trend does not appear to have been discussed or measured in the literature.

2.4.3 Comparisons in efficacy of approach

There are a variety of other approaches and interventions that have been designed to increase the social and communication skills of children and adolescents on the autistic spectrum, alongside the use of social skills groups. Children with autism have been found to be responsive to a wide variety of interventions aimed at increasing their social engagement with others, both adults and typically developing peers (Rogers, 2000).

Comparison studies have indicated that no individual approach has consistently been found to be more effective than any other. This suggests that limited generalisation of skill is common to all interventions designed to improve the social and communication skills of individuals on the autistic spectrum. In general, less research has been conducted specifically with young people with HFA and AS, which suggests that even less is known about which approach is most advantageous to this group of individuals.

Social engagement and naturalistic settings seems to play an important role in improving the ability to generalise the skills learnt, alongside the use of same age peers. An increase in self-confidence and self-esteem seems key according to the young people themselves, all of which would suggest greater thought being given to the way in which the learning of social and communication skills is presented. Direct teaching has not been found to be consistently conducive to learning and maintaining these skills. A group setting for more able young people on the autistic spectrum has been suggested as a good environment to develop 'comfort and confidence in social interactions' (Tse *et al*, 2007). Therefore a more naturalistic group setting aimed at promoting social engagement and improving confidence may perhaps improve generalisation rates.

This suggests that social and communication skills can better be generalised to other settings, if they are initially learnt implicitly through engagement in natural social processes in a safe environment. Seger (1994) defined implicit learning as learned complex information without complete verbalisable knowledge of what is learned. This would mimic the natural process that typically developing children go through, with the added feature of the specific intervention being offered to promote social engagement.

2.5 Why use assistive technology

The evidence for hyper-systemising alongside hypo-empathising in autism, suggests a corresponding desire to systemise the social world. However, due to the subtle nuances present in our development of social interaction, this can prove highly inefficient for those with an ASD. When we empathise, we respond in ways that acknowledge feelings of others and we are sensitive to other's different beliefs and perspectives (El Kaliouby *et al*, 2006). In addition, empathising allows us to share perceptual space with others, which is crucial for social learning, joint action, and joint attention (Baron-Cohen 1995). To make sense of a social situation, most people will naturally follow others' gaze

direction (El Kaliouby *et al*, 2006). When people focus on non-social stimuli (e.g., background objects), as is often the case in autism, they may miss the gist in the social interaction (Klin, Jones, Schultz, Volkmar, & Cohen, 2002; Klin, Jones, Schultz, & Volkmar, 2003).

Rather than focussing on a desire to improve empathy, interventions could work within an individual's existing cognitive style, utilising the system that they already use to make sense of the world around them. Technology and computers rely on strict, predictable systems made up of sets of rules that can be programmed, determined and understood. Use of such technology to assist in the development of social skills in an individual with an ASD would utilise an existing area of strength and engage them in an often existing area of interest and/or obsession. Many individuals with an ASD prefer to communicate with and through computers because they are predictable and place some control on the otherwise chaotic social world (Moore, McGrath & Thorpe, 2000). Anecdotal clinical evidence suggests a preference for role playing computer games, such as World of Warcraft and using avatar's, where you can design your own character and persona and interact with others through an online world.

Inclusion of technology could provide the ability to gain some mastery over a social situation and thus support the development of good self-esteem, which is vital in view of the susceptibility to high rates of co-morbid depression suggested in the literature within the high-functioning autistic population. Murray (1997) argued that computers are an ideal resource that could support the development of self-awareness, increase self-esteem and be an aid to effective communication, as they can motivate the individual to speak, read or to share their achievements. Hershkowitz (1997; 2000) also made a strong case for the usage of computers in therapy and education, reporting that the implementation of computer-based learning provides a very effective method for teaching language and academic skills to children with autism, and in helping adults to become independent. The question is therefore, how can we harness this interest in technology to systemise the social world (El Kaliouby *et al*, 2006) and/or help develop empathising ability?

The Department of Health and Human Services has called for new approaches that improve real-world functioning of individuals with autism, throughout their school-age

years and beyond (Department of Health and Human Services, 2004). The Cure Autism Now's Innovative Technology for Autism Initiative, intended to create a merger of technology with other fields, is yielding an interdisciplinary approach to the challenge of utilising technology to improve the lives of people with autism (Cure Autism Now, 2006).

Within the field of robotics, the use of the dolls as physical input devices has been found to encourage development of joint attention and turn-taking skills (El Kaliouby *et al*, 2006). Other robot platforms have been used for autism intervention, encouraging social behaviour, such as turn-taking and shared attention (Dautenhahn, Bond, Canamero & Edmonds, 2002; Scassellati, 2005). It is thought that robotics may also be useful for individuals at the higher end of the autistic spectrum, who would need help with the subtle, real-time social interactions (El Kaliouby *et al*, 2006). One can imagine a variation of LEGO©, already known to be helpful as an intervention in autism (LeGoff, 2004) that combines rules and mechanics to allow for social explorations (El Kaliouby *et al*, 2006). Robotics could be used by groups of children for improvisation and directing play, encouraging turn taking between children (El Kaliouby *et al*, 2006). Thus, using technology to provide a perhaps more comfortable environment, which is reliant on systemising to assist managing the social pressures within group task solution, could lead to more implicit or naturally occurring social responses.

2.6 Research into technology based interventions

While much of the work in affective computing has been motivated by the goal of giving future robots and computational agent's socio-emotional skills, its researchers have also recognised that they face similar challenges to those who try to help people with autism improve such skills (El Kaliouby *et al*, 2006). Computers, like most people with autism, do not naturally have the ability to interpret socio-affective cues, such as tone of voice or facial expression; similarly, computers do not naturally have common sense about people and the way they operate (El Kaliouby *et al*, 2006). This suggests a natural link, with opportunities for benefits to help people with autism, alongside helping technologies to be smarter about socio-emotional interaction.

Over the past 10 years, researchers in affective computing (Picard 1997) have begun to develop technologies that advance our understanding of, or approach to, affective neuroscience and autism (El Kaliouby *et al*, 2006). Affective computing has contributed

to these fields in at least four ways: (i) designing novel sensors and machine learning algorithms that analyse multimodal channels of affective information, such as facial expressions, gaze, tone of voice, gestures, and physiology; (ii) creating new techniques to infer a person's affective or cognitive state (e.g., confusion, frustration, stress, interest, and boredom); (iii) developing machines that respond affectively and adaptively to a person's state; and (iv) inventing personal technologies for improving awareness of affective states and its selective communication to others (El Kaliouby *et al*, 2006). Much of this falls under the category of affect sensing and recognition, which relies on equipment to recognise affect in others and/or the self through visual, auditory, motion, proximity or touch sensors. The aim being to provide the individual with additional information to support their interpretation of the social setting, to increase their awareness of their own affect or to increase interest in attending to particular features of the environment.

For example, individuals with ASDs tend to have a literal interpretation of what people say to them (Baron-Cohen 1988; Attwood 1998). Jonathan Bishop has developed a portable digital assistant (PDA) to help people with autism interpret frequently used idioms (Bishop 2003). There have also been a growing number of portable sensors developed that can capture various physical manifestations of affect. These novel sensors are like perceptual mechanisms and examples include tiny video camcorders to record facial expression, head gesture and posture changes, microphones to record vocal inflection changes, skin-surface sensing of muscle tension, heart-rate variability, skin conductivity, blood-glucose levels, and other bodily changes (El Kaliouby *et al*, 2006).

Technologies that sense various aspects of a person's affective and physiological state can be used to support the understanding of affect in others as well as be used for self-monitoring. For example, a wearable system that continuously measures stress or anxiety signals can help the wearer regulate their own level of arousal, helping them to raise their self-awareness (see El Kaliouby *et al*, 2006). This could provide useful information about attending to the individuals own levels of stress, enabling them to better manage their own emotional arousal in future settings.

Along with the potential benefits, there are some significant ethical considerations to take into account with the development of these technologies. Much of the equipment relies on sensing and recording other people who may not have given consent. This is of particular concern with recording equipment, which retains a copy of the information recorded. For some this could be considered to be impinging on a person's privacy, as they would have no control over what the recording was used for. Another ethical consideration is whether exposing affective state information in the self, creates opportunities for others to manipulate one's behaviour and thoughts using this information (see Reynolds, 2005 for examples). Even in situations where the use of technology is honest, if an individual with autism wears an assistive system that senses the affective state of others, then this could raise the expectations of interaction partners, increasing (rather than decreasing) the social pressures on the person with autism to respond to these cues in real time (El Kaliouby *et al*, 2006).

In light of the often low-levels of self-esteem felt by individuals with HFA and AS, it would also be important to consider how obvious these technologies are as they rely on being worn. Individuals with an ASD can remain largely ambiguous in society and a piece of computer equipment being worn could be very obvious to the people they are interacting with. Although they started off as bulky, affective 'wearables' now seem to be able to be embedded in jewellery or woven into clothing (Picard & Healey, 1997). The continual advancement of technologies being able to be made smaller and smaller may make individuals with an ASD more likely to make use of such devices, however this again raises the ethical issue of others being recorded without their knowledge.

In relation to supporting the individual with an ASD to make more appropriate real time social responses, the use of such technologies will inevitably present a time lag between using the output from the equipment and responding appropriately to another person. This runs the risk of causing embarrassment, creating awkward situations or make conversations seem stilted.

Within therapeutic or educational settings the use of technology seems to have taken on a less conspicuous form, by aiming to enhance the individual's own abilities, rather than adding a physical aid. The types of interventions vary dramatically, such as using LEGO as an aid, using virtual reality, animated characters and robotics, which all require

different levels of interactive multimedia. Typically, the aim appears to use naturally reinforcing materials and activities (Owens, Granader, Humphrey & Baron-Cohen, 2008).

For example, LEGO therapy (LeGoff, 2004) is based on the idea of using the child's natural interests to motivate learning and behaviour change. Although not specifically a 'technology', a typical LEGO therapy project would aim to build a LEGO set, importantly with a social division of labour (Owens *et al*, 2008). Research into its use with individuals with an ASD is promising, with significant improvements in social interaction being reported. These studies are limited in number but are producing consistent results. LEGO therapy has been found to show significant improvements in comparison to other interventions and to no intervention at all (see LeGoff, 2004; LeGoff & Sherman, 2006; Owens *et al*, 2008). Consideration has been given to the use of autism specific outcome measures, with the Gillian Autism rating Scale (GARS; Gilliam, 1995) being used across studies (in conjunction with other measures), which enables the results to be compared. The magnitude of the improvements reported is small, but this is also consistent across studies.

Computers have also been described as 'highly effective teaching mediums for individuals with ASDs' (Beaumont & Sofronoff, 2008). They capitalize on a common special interest (Gray, 1998), allow for self-paced learning, provide immediate feedback, and minimize the need for 'real world' social interactions for the acquisition of information: a common source of anxiety for individuals with ASDs (Golan & Baron-Cohen, 2006). They have been used to develop interactive multimedia programmes aimed at supporting the development of social and communication skills in young people across the autistic spectrum. Initial research is minimal; however the potential for this form of intervention for individuals with ASDs has been proposed consistently in the available literature.

Beaumont & Sofronoff (2008) developed a multi-component social skills intervention for children with AS, which included a computer game entitled the 'Junior Detective' programme. The children were required to play the part of a secret agent, using their spying abilities to decode suspect's thoughts and feelings and to complete virtual reality missions such as bullying, dealing with others and trying new things. Relative to the waiting list control group, greater improvements in social skills were reported, with

significant statistical improvements noted on parent-rated measures. Clinically significant improvements were noted specifically on Spence's (1995) social skills questionnaire. Completion of the computer game was coupled with small group sessions, parent training sessions and teacher handouts.

Virtual reality has been proposed as a forum to minimise the need for real-time social interactions by providing an environment in which to 'allow the safe and non-threatening practice of particular skills in an educational setting' (Parsons & Mitchell, 2002). Virtual environments have been designed to teach social life skills, rehearse problematic real life situations and to learn how to better cope with the real world, for example, recognising emotions, crossing the road and learning where and how to sit down in a populated cafeteria (e.g., Strickland, 1996; 1998; 2004). Furthermore, they are also designed to help children with autism learn how to recognise social displays of affect and explore different emotional situations by themselves (e.g., Blotcher & Picard, 2002). The research suggests that this could be a useful forum for young people with an ASD, however studies are limited and the need for further exploration is highlighted.

For example, Blotcher & Picard (2002) found that children with ASDs were able to make emotional matches between images presented as part of a computer programme and dolls expressing similar emotions. The sample included children aged two-to-nine years with different levels of functioning. The older and/or higher functioning individuals seemingly performed better, with some evidence being found for improvement over time. However no baseline or outcome measures were taken and it was unclear what led to the improvements for those particular children.

Strickland (2004) discusses the design of a virtual shop, using clothing and public transport scenarios with autistic children. However no information is provided about their ages or level of functioning. Teachers of children with a learning difficulty have already confirmed the usefulness of this package and the suggestion is that this could be a practical resource for the education of autistic children. No results have yet been presented, as evaluations are ongoing.

Baron-Cohen and colleagues (2007) developed an animated series called *The Transporters*, which was aimed at relatively neglected ('excluded') people on the autistic

spectrum: those with significant learning difficulties (low-functioning individuals), and preschoolers. Neither of these two groups may have the ability or interest to use a computer, but both of these two groups enjoy watching animated films about vehicles (Baron-Cohen, Golan, Chapman & Granader, 2007). According to the hyper-systemising theory (Baron-Cohen, 2006), vehicles whose motion is determined only by physical rules (such as vehicles that can only go back and forth along linear tracks) would be much preferred by children with autism over vehicles like planes or cars, whose motion could be highly variable (Baron-Cohen *et al*, 2007).

The animated series was therefore designed with eight characters, on to which were grafted real-life faces of actors, validated for the emotion that they were meant to be conveying and contextualised in entertaining social interactions between the toy vehicles. *The Transporters* aims to teach not just some basic emotions (happy, sad, angry, disgust, fear, surprise) but also some more complex ones (ashamed, joking, jealous, proud, tired, sorry, kind, excited, worried, unfriendly and grumpy) (Baron-Cohen *et al*, 2007). The hypothesis being that through hours of repetitive TV watching, that children with autism will tune into faces without even realising that they are doing so, i.e., that 'they would become familiar with how people look when they are surprised or afraid or proud through massive exposure to these patterns' (Baron-Cohen *et al*, 2007).

An initial evaluation of *The Transporters* (see Golan, Baron-Cohen, Ashwin, Granader, McClintock, Day & Leggett, in press) reports an improvement in understanding and recognising emotions from baseline (time one) to post intervention (time two). With the intervention group improving significantly more than the control group, alongside scoring comparable to typically developing peers at time two. Statistically significant differences are reported between scores at time one and time two for the intervention group only. Further evaluations of *The Transporters* DVD are planned.

There have been some concerns about colluding with the social disability of ASDs. For example, Howlin (1998a) suggested that an overreliance on computer interaction could lead to obsessive behaviour and a decline in real-world interaction. Latash (1998) also commented that virtual reality could become too safe and too attractive, so that the young person could become a computer addict and be reluctant to re-enter the real world. However, the main cause of obsessive behaviour in relation to computer use in

ASDs is the predictability of programming. Therefore, the incorporation of more flexible, unpredictable events in virtual environments might go some way to overcome this concern. Programming could ensure the young person would not be able to use the computer in a passive way, but would need to think about the required response in order to proceed further; consequently, the young person's interaction with the computer would be more active, less predictable, and therefore, less obsessional (Parsons & Mitchell, 2002). Secondly, a virtual environment for social skills training would best be used in collaboration with other people. The aim is not to circumvent real-world social interaction altogether, but to provide a teaching aid that would allow practice and demonstration alongside normal 'real world' input from a teacher or support worker (Parsons & Mitchell, 2002). Thus, real-world social interaction can be incorporated by the presence of teachers and parents sitting alongside the person with autism (Murray, 1997) and 'real world' social opportunities with peers still being encouraged.

There is also some encouraging evidence from typically developing children to suggest that interaction with another person during the use of computer-based tasks significantly improves learning outcomes. For example, Mevarech, Silber & Fine (1991) found that, when children worked in pairs on computer-based tasks, they were significantly more likely to demonstrate improvements in learning compared to children who worked individually.

A major area of research within the field of mobile robotics is in their use to aid the disabled or handicapped (Werry & Dautenhahn, 1999). One area is an extension of the wheelchair and involves the use of robots to perform tasks, which not only directly affects the user, but are also a consequence of a user's actions and requests (see Bolmsjo, Neveryd & Eftring, 1995; Wilkes, Alford, Pack, Rogers, Peters II & Kawamura, 1998). Since the intended user will be without any specific training and is often unable to perform a specific type of task due to a disability, the design and interface of the robot is critical (Werry & Dautenhahn, 1999).

Within the area of robotics and ASD, research is increasingly being presented to suggest the usefulness of robot-human interaction in supporting the development of improved social functioning in young people on the autistic spectrum. For young children and those at the lower end of the autistic spectrum, sociable robotics and dolls have been

suggested as a good approach to supporting the development of social interaction skills. The use of robots allows for a simplified, predictable and reliable environment, where the complexity of interaction can be controlled and gradually increased; it is also more realistic and engaging than interacting with a screen (El Kaliouby *et al*, 2006).

Michaud and colleagues (2002; 2003; 2003; 2005) studied the use of mobile robotic toys and explored various robotic designs, e.g., a spherical robotic ball 'Roball', a robot creature with arms and a tail, and a mobile humanoid structure on wheels 'Tito'. They presented playful interactions of children with autism and robots as part of an engineering project, focused on exploring the design space of robots that can facilitate interactions with children. As a result, the outcomes of these playful interactions were presented in a narrative account, with no systematic evaluations conducted, either qualitative or quantitative. Little is also known about any specific therapeutic/educational benefits to the children, nor about the history of the children. Other work that studies the playful interactions between children with ASDs and robots have been carried out by Wada, Shibata, Saito & Tanie (2002) who developed a seal pet robot called Paro as an assistive tool in rehabilitation and robot assisted activity. However, narrative accounts are again presented, giving little information about the specific nature of the therapeutic effects that can be linked to the robot.

Further studies have provided evidence of robots encouraging and facilitating social behaviour in children with autism through embodied social interaction (see Feil-Seifer & Mataric, 2008) as well as prompting spontaneous play (see Kozima, Nakagawa & Yasuda, 2005). Robots have been found to provide a focus of attention, with statistical analysis of behavioural observations revealing that children with autism direct significantly more eye gaze and attention toward a robot than a non-robotic toy (see Dautenhahn, Werry, Rae, Dickerson & Stribling, 2002; Werry, Dautenhahn & Harwin, 2001; Werry, 2003). Evidence for robots as a focus for joint attention has been presented through gaze and attention data, alongside evidence of interaction between pairs of children (see Fasel, Gedeon, Triesch & Movellan, 2002; Robins, Dautenhahn, te-Boekorst & Billard, 2005; Robins, Dickerson, Stribling & Dautenhahn, 2004).

Little is know about the impact of robotics on those at the higher functioning end of the autistic spectrum. However, it has been hypothesised that they could support the

development of real-time social interactions; possibly through use in groups to promote improvisation and by encouraging turn-taking (see El Kaliouby *et al*, 2006).

2.7 The AuRoRa project

The Aurora project (**Au**tonomous mobile **Ro**bot as a **R**emedial tool for **A**utistic children) investigates the potential use of robots as therapeutic or educational 'toys' specifically for use by children with as ASD. The main aim is to engage children with autism in coordinated and synchronized interactions with the environment thus helping them to develop and increase their communication and social interaction skills (Aurora, 2009). Specifically, the project aims to facilitate turn taking and imitation, in addition to encouraging general communication and social interaction skills required for human-human contact (Aurora, 2009). The Aurora team use both humanoid and non-humanoid robots in their research. The project has so far used a series of prototypes and evaluated their interaction with children with an ASD. It is an ongoing longitudinal project, which began in 1998.

The main research aims proposed by the Aurora project team are:

- To develop behaviour-based control architecture for an interactive robotic platform, so that the robot functions as an interactive "toy" and can express more complex behaviours, depending on the interaction with a child, or a small group of children.
- To test the suitability of different robotic platforms, including mobile, as well as humanoid robots.
- To develop robot controllers so that the robot can identify and adapt to different play patterns of children interacting with the robot.
- To investigate different qualitative and quantitative evaluation techniques in order to point out the communicative competencies of children with autism in interaction with robots.
- To develop a model of child robot interaction where the robot acts as a mediator and an object of shared attention, encouraging the child to interact with peers (other children) and adults (teachers, carers, parents).

- In addition to the above-mentioned robotics related issues, to also investigate how interactive software can access and develop story-telling and narrative skills in children with autism.
- To investigate and develop new methods in Robot Assisted Play for children with special needs.

Primarily their research has focussed on working with low functioning individuals with an ASD, often with little or no verbal ability. Initial research involved individual case studies to observe human-robot interaction (e.g., Dautenhahn *et al*, 2002; Werry *et al*, 2001; Werry, 2003). Individual children paid acute attention to the robots, enjoyed interacting with them and explored the robots various behaviours. They found that robots were able to instruct the children in roles of turn taking by providing a sequence of actions and by both prompting the children and waiting for a specific stimulus from them.

The project moved towards involving an adult and/or one other child to provide information on human-human interaction with the aid of a robot (e.g., Robins *et al*, 2004; Werry, Dautenhahn, Ogden & Harwin, 2001). The robot was able to provide a focus of attention and of joint-attention. The robot's role as a social mediator became apparent in how the children interacted with the other people present in the room, including child-teacher, child-investigator and child-child interactions. The project continues to conduct research into the robots role as mediator, using both humanoid and non-humanoid robots.

The current focus of their research has been on a robots ability to foster collaboration between children and is the first look at both high-functioning individuals and the use of more than pairs of children (see Wainer, Dautenhahn & Robins, 2008; Wainer, Ferrari, Dautenhahn & Robins, in press). This exploratory study investigated the frequency and type of interaction between children, through observational data collected through coding video recordings. At present, no quantitative data has been collected, with any use of standardised outcome measures. Typically behavioural data has been collected through observation to provide accurate measures of real-time interaction.

2.8 Present study: The Robot Club

The present study aims to pilot the use of a non-humanoid robot in a group setting for young people with either HFA or AS. The inclusion of a robot in a group setting aims to provide a focus of shared attention in a more naturally occurring and systemisable environment; thus being better able to promote implicit learning of social skills. The robot by definition will be governed by a set of predictable and physical rules, placed in an environment that warrants a greater level of flexibility for social success. This study aims to expand upon Wainer *et al.* (2008) exploratory study, utilising a more structured small group setting, including the use of standardised outcome measures aimed specifically at measuring social skills functioning, communication skills and problem behaviours in ASDs.

The purpose of this study is to conduct a careful detailed assessment and observation of this form of intervention for this higher-functioning autistic population. It is hoped to determine whether the young people attending the group show improvements in social skills functioning and/or improvements in areas other that social skills functioning. It is also hoped to determine whether there are any significant social skills or other improvements in the clinical sample as compared to a comparative control group.
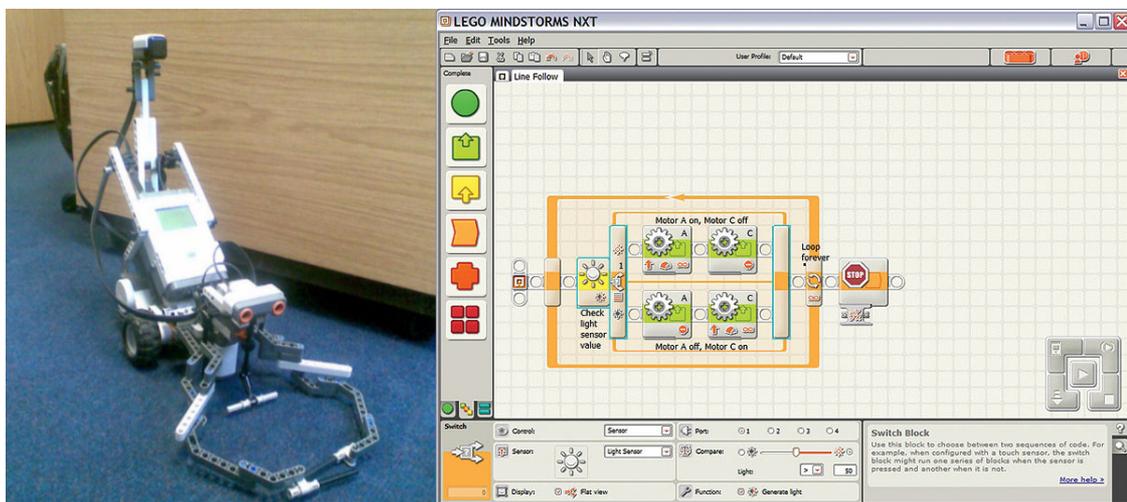

Figure One: Left: One of the LEGO Mindstorms NXT robots. Right: A screen capture of the computer programme used to programme the robots (the NXT-G graphical environment). (Wainer et al, 2008).

The robots to be used in this study are LEGO Mindstorms NXT robots (see figure one). These are non-humanoid robots, which are freely available to buy. They use a variety of

sensors to explore their environment and rely on information downloaded from the LEGO Mindstorms NXT computer programme (see figure one) to navigate their environment appropriately. The robots connect to a computer through USB portals and are designed for use by both children and adults.

2.8.1 Aims

The primary aim of this study is to assess the impact of using a non-humanoid robot to promote social engagement in a group of young people with either HFA or AS. The main objective is to provide a more natural environment that relies on systemising to provide the social pressure for task solution; thus hopefully leading to more implicit or naturally occurring social responses, alongside a better ability to generalise those responses to other settings. The aim is therefore to explore the means through which this intervention may exert its effects on selected clinical outcomes and experimental variables using specific outcome measures. It is hypothesised that through engaging in a social setting that relies on systemising, that more appropriate social and communication skills will be exhibited upon completion of the group, as measured by the selected outcome measures.

A secondary aim is to compare the trajectories of the individual participants across the course of the group, to determine if there is a pattern of improvement.

An additional aim is to compare the problem behaviour, and social and communication skills of those attending the robot club, to a clinical control group of non-attenders.

2.8.2 Hypotheses

Based on the understanding that exposure to a natural social setting where systemising is necessary will lead to more implicit learning of necessary social and communication skills, the following directional hypotheses have been proposed to be tested one-tailed:

1. Attendance at the robot club will lead to improvements in the social skills functioning of young people with either HFA or AS as measured by autism specific social skills scales.

2. Attendance at the robot club will lead to improvements in the communication skills of young people with either HFA or AS as measured by autism specific communication skills scales.

3. The extent of similarities in individual trajectories may differ depending on factors such as age or academic functioning.

The hyper-systemising theory probably does not predict that obsessional / stereotyped behaviours will decrease with social skills intervention, as this is not directly linked to empathising but more involved with systemising behaviour.

However clinical observation suggests that stereotyped behaviour will increase with increased anxiety and decrease when stress is minimal. It is clear from personal accounts written by individuals with autism that stereotyped and ritualistic behaviours are extremely important methods of reducing stress and anxiety, and such behaviours are much more likely to occur if children are placed under too much pressure (Howlin, 1998b). It is predicted that as the robot club progresses, that the young people will become more relaxed and confident in this setting. The following hypothesis is therefore proposed.

4. Attendance at the robot club will lead to a reduction in problem behaviours exhibited by young people with either HFA or AS within the group setting.

3. Method

3.1 Design

This study employed a group level and a series of single case studies pooled together for multiple and individual base line comparisons. This design enabled an analysis of group performance as well as individual gains and losses across the intervention period to be assessed. The focus on individual trajectories as well as overall group performance was to search for individual variations that may perhaps be hidden by averaging an overall group trajectory. To improve the design of the study, the aim had also been to include a comparative control group. The addition of a comparative group aimed to improve the strength of the study to detect therapeutic rather than possible additional development effects. Unfortunately, no families consented to participate as part of the comparative control group. Analysis was therefore planned for the intervention group only.

3.2 Participants

Participants were recruited through a voluntary agency run by parents for young people with an ASD and their families. The family support group meets weekly during term time in a local secondary school, allowing the young people and their families to meet and informally support others experiencing similar challenges to themselves. The young people typically range in age from 8-14 years, with an average age of 10-years-old and the majority are male. Given its school based setting, the sample site thus has good ecological validity and this may assist with generalising any possible effects of the programme. Parents were provided with an information sheet (see appendix A) outlining the purpose of the study and what would be involved. Both parents and their children were given the opportunity to ask questions about the study in order to gain informed consent for participation (see appendix B for consent form). Young people meeting the criteria for either HFA or AS were eligible to participate. Informed written consent was gained from parents and the young people themselves where able. The group itself was run during the existing meeting time for the family support group, in order to facilitate participation. This was arranged in agreement with parents to allow all those interested in participating to attend.

In order to determine a sufficient sample size for this study, a prior power analysis was carried out. A strong effect size was assumed (Cohen's dz of 0.80) regarding

improvement, in terms of the mean difference from baseline to the end of the intervention on relevant outcome measures. The corresponding power analysis revealed that a sample size of 12 would be sufficient to detect this effect size with a power of 0.82 (see figure one below) and an alpha error of 5% (one-tailed).

T tests - Means: Difference between two dependent means (matched pairs)

Analysis: A priori: Compute required sample size

Input: Tail(s) =   One
              Effect size dz =   0.80
              α err prob =   0.05
              Power (1-β err prob) =   0.8

Output: Noncentrality parameter δ = 2.771281
              Critical t =   1.795885
              Df =   11
              Total sample size =   12
              Actual power   =   0.828981

Figure Two: Prior power analysis output from GPower3

A group of 11 young people consented to attend the robot club, ranging in age from 7 years 7 months to 14 years 9 months at the start of the intervention (mean age = 10 years 5 months, SD = 1.99 years). All participants were male, with ten attending mainstream school and one being home schooled by his parents. Six had a diagnosis of HFA and five a diagnosis of AS with all having been formally diagnosed. All participants were verbal. The majority of participants were of white British origin or of mixed ethnicity, including black African, Asian and Russian decent.

3.3 Length of intervention

The robot club ran for a total of eight sessions. It had originally been planned to run for ten sessions, however due to time constraints, including adverse weather conditions making it difficult for families to travel safely, the total number of sessions were reduced. Given the paucity of research in this area it was difficult to determine the minimum number of sessions that would be sufficient to engender change. Existing research into generic social skills groups for this population vary dramatically in length, for example Kamps et al (1992) running a four session initial programme including typically developing peers, compared to Ozonoff & Miller (1995) running for a total of fourteen

consecutive weeks. For those groups run specifically for young people with HFA and/or AS, eight weeks seems to be the norm (e.g., Barnhill *et al*, 2002; Barry *et al.*, 2003). It was therefore felt that for this study, a minimum of eight sessions would be sufficient in the first instance.

3.4 Setting

Two separate robot club sessions were run consecutively each week after school, lasting an hour each. The eleven participants were randomly allocated into two groups, unless their parent(s) specified that they were only able to attend at a particular time due to travel or other child care arrangements. There were five participants in the first group and six in the second. The young people consistently attended the same group throughout and the same room was used throughout.

Three researchers were present during each session. Two to facilitate the robot club itself alongside collecting data from parents and the young people at each session and one to provide technical support where necessary through supporting the young people when they had difficulties making their robots behave as desired, in addition to providing some specialized software for the interactive arena in which the robots interacted.

3.5 Details of intervention

Individual features of the intervention were used and adapted from Wainer and colleagues (2008) template of children programming Lego NXT robots using specific sensor suite and construction, with the robots programmed to interact with each other and the children; a specially-constructed arena equipped with Phidget sensors which automatically rewarded the children with flashing lights and pleasant sounds for making the robots interact in specific ways; classes divided into sessions for learning about robotic programming and for play; and for small groups of children to rotate between three distinct roles (programming, downloading and testing the robot) during play. Three identical Lego Mindstorms NXT robots were used each week, which enabled the young people to work predominantly in pairs. Power point slides were developed for each session to provide structure to the groups, using both written and pictorial aids to cater for different learning styles and different levels of reading ability (see appendix C for slides). Games and interaction with each other and the robots, were interspersed with minimal didactic teaching to teach new ways to programme the robots at each session.

The participants were taught how to use the Lego Mindstorms computer programme to develop instructions controlling the robot's movements, as well as the level of interaction with both the other robots and the young people themselves. They learnt how to download the instructions to the robots and to then watch the sequence take place. Each group developed their own set of group rules at the start of the first session and these were pinned up on the wall at each subsequent robot club session. Although no formal social skills training took place, the young people were supported to work successfully in pairs (or threes where necessary), to programme their robots. Each pair/three were required to take on different roles for each task (e.g., giving instructions verses controlling the computer programme verses downloading the programme verses checking for accuracy) and were encouraged to rotate roles for each new task. Where necessary, the young people were supported in their role delegation by the facilitators and in negotiating the subsequent interactions, if for example, a disagreement broke out. Each participant then rated how close they were to reaching their individually set goals at the end of each session.

During the sessions, the young people learnt about how the robots used their different sensors (light, compass and touch) and why those sensors were important to understanding their environment. They learnt how to control the robots movement (direction and speed), to wait for something specific to happen or for a specific interaction, to interact with the other robots and/or the participants themselves, and to repeat sequences inside a loop. In order to be successful in programming the robots, they needed to work together to check the accuracy of the sequence and to interact with the robots.

3.6 Measures

The measures used in this study can be found in appendix D in the order in which they are presented here.

3.6.1 Social skills

<u>Gilliam Autism Rating Scale - 2nd Edition</u> (GARS-2; Gilliam, 2006): The GARS-2 is a norm referenced measure designed to assist teachers, parents and clinicians in identifying and diagnosing autism in individuals aged 3 through 22. It also provides information on the severity of the disorder. Items on the GARS-2 are based on the

definitions of autism adopted by the 'Autism Society of America' and the 'Diagnostic and Statistical Manual of Mental Disorder: Fourth Edition - Text Revised' (DSM-IV-TR). The measure consists of 42 items describing characteristic behaviours of individuals with an ASD grouped into three subscales: stereotyped behaviours (1), communication (2) and social interaction (3). Each item is given a frequency-based rating on a four point scale, dependent on how often the rater has observed that particular behaviour in a specified 6-hour period. Standard scores are computed for each of the three subscales along with an overall autism index score to determine the probability of autism. Additional sections are available to complete regarding early behaviour prior to three-years along with a structured parent interview to provide examiners with diagnostically significant information about the child's development. These sections were not used as part of this study as each participant already had a diagnosis.

The GARS-2 was normed on a representative sample of 1,107 individuals with autism from 48 states within the United States, with the demographic characteristics of the normative sample being based on the 2000 U.S. Census data (Gilliam, 2006). This measure is a revised version of the GARS (Gilliam, 1995), which was found to have strong psychometric characteristics confirming the measures reliability (internal consistency and test-retest) and validity. Coefficients for the internal consistency of each subscale were reported as .84 (stereotyped behaviours), .86 (Communication) and .88 (social interaction) and for test-retest reliability as .90 (stereotyped behaviours), .70 (Communication) and .88 (social interaction). The validity of the GARS-2 was demonstrated by confirming through several studies that: (a) the items of the subscales are representative of the characteristics of autism; (b) the subscales are strongly related to each other and to performance of other tests that screen for autism; and (c) the standard scores discriminate individuals with an ASD from individuals with other severe behavioural disorders, such as those with a learning disability and co-morbid difficulties (e.g., Montgomery, Newton, & Smith, 2008).

Social Skills Improvement System (SSIS; Gresham & Elliott, 2008): The SSIS is a norm referenced measure designed to assist professionals in screening and classifying students suspected of having social skills deficits. It uses a multi rater approach that can include ratings from teachers, parents and the students themselves to document the frequency (on a four point scale) and perceived importance (on a three point scale) of

both positive and problem behaviours. The SSIS is a revision of the widely used Social Skills Rating System (SSRS; Gresham & Elliott, 1990) and assesses skills across three domains, (1) social skills, (2) problem behaviours and (3) academic competence. The social skills scale measures positive social behaviours in the sub-domains of communication, cooperation, assertion, responsibility, empathy, engagement and self control. The problem behaviour scale measures behaviours that can interfere with either the acquisition or performance of socially skilled behaviours in the sub-domains of externalising, bullying, hyperactivity/inattention and internalising. The parent and teacher versions include the addition of the sub-domain autism spectrum, which makes it specifically relevant for this study. The teacher version also includes the additional academic competence scale to provide an estimate of academic functioning. Teachers rate reading and mathematics performance, motivation, parental support and general cognitive functioning. The student rated forms are available for 8-12 years and 13-18 years.

The SSIS was normed on a standardised sample of 4,700 young people ages 3 to 18 years, representing the US population according to gender, race, socioeconomic status and geographic region. Combined and gender-specific age-based norms are provided for all forms. The SSIS was found to have strong psychometric characteristics confirming the measures reliability (internal consistency, test-retest and inter-rater) and validity (based on internal structure, relation to other variables and to specific population groups). Coefficients for all these psychometric characteristics for the parent and teacher rated forms typically fall between .73 and .93, with the student rated forms falling slightly lower in the .60s and .70s.

3.6.2 Behaviour

<u>Strengths and Difficulties Questionnaire</u> (SDQ; Goodman, 1997; Goodman, Meltzer & Bailey, 1998): The SDQ has received a lot of attention since its development, and seems to have become one of the most commonly used screening rating scales, for measuring emotional and behavioural difficulties, particularly in clinical settings. Studies have sought to compare the SDQ with previously validated and lengthier questionnaires (e.g., Goodman & Scott, 1999), and the reliability of various translations have also been investigated. The SDQ is described as having a variety of uses, and has parent, teacher and self-rated versions available in a variety of languages. The SDQ is both brief and

also widely available and free to use, which may also contribute to its wide usage in both clinical and non-clinical settings. This scale is currently being employed by the CAMHS Outreach Research Consortium (CORC) in their aim to institute a common model of routine outcome evaluation across the full range of Child and Adolescent Mental Health Services (CAMHS) in the UK.

The SDQ is valid for completion by parents and teachers of children aged 3-16, with a self-report version for children aged 11-16. It is a brief behavioural screening questionnaire, which provides a profile of scores across five scales, a total difficulties score and a measure of the impact this is having on different areas of their life. Pre-intervention and follow up versions are available. Emotional symptoms (ES), conduct problems (CP), hyperactivity/inattention (HI) and peer relationship problems (PR) are the four negative scales, the individual scores generated for these four scales are added together to generate the total difficulties score (TD). Pro-social behaviour (PS) represents the positive scale or strength measured, and is the fifth scale. Scoring for each scale ranges from zero-to-ten, total difficulties score therefore ranges from zero-to-forty.

Parent rated behaviour checklist: This is a non-standardised measure that was developed in London at Guy's Hospital's neurodevelopmental service by Dr Nick Wood, Research Tutor and Consultant Clinical Psychologist, along with the Speech and Language Therapist Vicky Slonims, specifically for individuals with an ASD. It contains twelve items classified as asocial or inappropriately social and eight items classified as pro-social. Each item is given a frequency based rating on a five point scale. The ratings are summed to provide scores for each scale, providing information on typical autistic behaviours alongside a measure of strength and adaptive functioning. This measure has not been validated and has been included in this study alongside other standardised measures, to provide additional anecdotal information relating specifically to behaviours typical of ASDs. This measure in particular was included, as it provided additional ratings of further positive pro-social behaviours and not just social difficulties or dysfunction.

3.6.3 General level of functioning

Child Global Assessment Scale (CGAS; Schaffer, Gould, Brasic, Ambrosini, Fisher, Bird & Aluwahlia, 1983): The CGAS is a clinician rated scale that provides a global measure

of level of functioning in children and adolescents aged 4-to-16 years. The measure provides a single global rating on a scale of 0-100. A glossary is provided to aid the clinician to determine the meaning of the points on the scale, enabling them to rate each individual based on their observations of that young person. The young person is rated at their most impaired level of general functioning during that time period by selecting the lowest level which describes their functioning. A rating is given regarding actual functioning regardless of treatment or prognosis. This scale is widely used in clinic settings and is also currently being employed by CORC.

3.6.4 Self-descriptions

Goal based outcomes: In order to further evaluate the impact of the robot club on each young person, it felt appropriate to use the addition of individual targets in conjunction to other standardised measures. Initially I had considered the simplified personal questionnaire (Elliott, Mack & Shapiro, 1999), which requires the individual to generate problem descriptions and rate them on a seven point scale based on how much that problem has bothered them in the last week. I piloted this method with two of the participants and they struggled with the concept of a higher rating representing the negative pole. The young people were better able to generate goals based on the things they found difficult in a group setting and to rate them according to how close they were to achieving each individual goal. This method of producing goal based outcome measures has been adopted by CORC as part of their national evaluation of CAMH services and has been found to work well with children and adolescents, as it enables them to choose their own goals based on what they would like to be different. The participants were supported to generate their own goals and to rate them on a ten point scale. The higher the rating, the closer they believed they were to reaching their goal.

Evaluation form: An evaluation form was designed for both parents and the young people themselves to complete upon conclusion of the robot club. This was to provide a forum to gain feedback on the group from a qualitative perspective. Open ended questions were used to prompt richer responses regarding what was perceived as working well or being unsuccessful, alongside what, if anything, had been learnt about being in a group setting.

3.7 Procedure

Families were initially made aware of the study by the volunteers running the family support group and a date was arranged for me to begin attending their meetings. Over a series of meetings I met with families to talk about the study and answer any questions. The information sheet and consent form were made available to families prior to my first visit, distributed by the volunteers via the support groups e-mailing list and in paper format on subsequent visits. Participants were recruited based on the presence of a formal diagnosis of either HFA or AS. No young people were excluded from attending the robot club unless they did not have either relevant diagnosis. Parents were relied upon to provide conformation of a diagnosis, either through written documentation or by initiating contact with the diagnosing clinician via telephone or e-mail. The families retained all documentation. All participants had been diagnosed by either child and adolescent psychiatrists or paediatricians. Where conformation was not possible, the GARS-2 was used as a screening tool. The majority of participants scored in the 'very likely' probability of autism category with two scoring in the 'possibly' range for their overall autism index score. The remaining two scored across the probably and unlikely categories for the three domains, however both these young people had a formal diagnosis of AS. It is important to note that the GARS-2 on its own is not a sufficiently robust diagnostic tool, without inclusion of additional information, for example, a detailed developmental history.

When signed consent forms were returned, families were asked to complete a series of baseline measures alongside a participant demographic information sheet. To facilitate the return of completed questionnaires, these were completed during the family support group meetings and handed back immediately wherever possible. Parents were asked to complete questionnaires and return them before leaving each week. The young people themselves were supported to generate their own goals and to complete their own questionnaires where necessary. Teacher rated questionnaires were given to parents along with a covering letter and a copy of the information sheet, requesting completion and return to parents by the robot club's start date. The clinician rated measure was scored by the two group facilitators to improve inter-rater reliability, on the basis of spending time with each young person in the weeks preceding the robot club meetings. All baseline measures were completed either prior to, or during, the first robot club session.

At subsequent sessions, select questionnaires were again completed and returned immediately where possible. At the final session, the full set of outcome measures were again completed. The same parent for each child completed the questionnaires each week. Teacher rated versions were provided to parents two weeks in advance of the final session, requesting completion and return in that final week. For the young person that was home schooled, the second parent was able to complete the teacher rated questionnaires, considering their child's behaviour solely during teaching hours.

The outcome measures were completed at each robot club session as follows:

Baseline measures / week one
1. Parent rated SDQ
2. Self rated SDQ (if participant was 11-years or older)
3. Teacher rated SDQ
4. GARS-2 (parent rated)
5. SSIS parent rated
6. SSIS self rated (if participant was 8-years or older)
7. SSIS teacher rated
8. Parent rated behavioural check list
9. Goal based outcomes
10. CGAS

Weeks two through seven
1. GARS-2 (parent rated)
2. Goal based outcomes

Week eight / outcome measures
1. Parent rated SDQ
2. Self rated SDQ (if participant was 11-years or older)
3. Teacher rated SDQ
4. GARS-2 (parent rated)
5. SSIS parent rated
6. SSIS self rated (if participant was 8-years or older)
7. SSIS teacher rated

8. Parent rated behavioural check list
9. Goal based outcomes
10. CGAS
11. Evaluation form - parent rated
12. Evaluation form - self rated

The initial plan had been to collect data from a variety of sources, including video recording each group session. However due to time constraints, the video data has not been able to be analysed alongside the other data collected. The plan is to conduct additional analysis of this data in the future, to provide a richer source of information regarding the impact of this form of intervention. Specifically, coding the video sequences for the behavioural and emotional interactions observed between the young people and with the robots.

3.8 Ethical issues

Prior to undertaking any participant recruitment, ethical approval was sought and gained from the University of Hertfordshire's School of Psychology (see appendix E for ethics application and approval certificate). This study was also linked to the Aurora project in the School of Computer Science within the university, being granted ethical approval alongside their existing protocol.

Although this study involved working with young people under the age of 18-years who had social and communication difficulties, it was felt not to raise any significant ethical implications. There was no deception involved, which enabled families to be provided with detailed information regarding the nature of the study. Both parents and their children were able to ask questions about the study and the robot club itself and therefore, give informed consent. The young people and/or their parents were also able to withdraw from the study and the robot club at any time.

The specific outcome measures used were considered carefully in terms of their relevance to ASDs, alongside the total number to complete, their length, their content in relation to sensitive topics and those specifically to be completed at each group session, in order to facilitate participation and keep the level of stress to a minimum. In view of the preference for familiarity and routine often experienced by those with an ASD, the venue

and timing for group sessions was also considered in order to reduce anxiety levels. Although not participating in the actual group sessions, parents were either present in the room during sessions, or remained in the rooms used by the family support group near by. This served to alleviate any anxieties the young people or their parents had about attending the group and enabled parents to be easily contacted if their child became distressed for any reason.

All information collected during the course of the study has remained confidential. Clear guidelines were put in place at the start of the study to explain the limits of confidentiality and families were advised of the appropriate actions if this became necessary.

Specific ethical considerations were given to the use of video recording equipment. The benefits of recording were explained to parents and only upon consent from all participants did this go ahead. Both the parents and young people themselves where appropriate, were also asked specifically if they were happy for still images to potentially be included in the write up, as pictures would be unable to remain anonymous in the same way as written information.

3.9 Planned analyses

Seven of the participants attended almost the full number of sessions for the robot club, missing sessions only for illness. In these cases, missing values were substituted for neighbouring interpolation values where possible. The remaining four participants dropped out at different stages of the programme. Two participants missed the final two sessions due to difficult family circumstances including illness and bereavement. One participant had a problematic relationship with another member of the robot club, which made it difficult for them to remain without getting distressed. He made the decision to miss part or all, of the final four sessions. The final participant attended the first three sessions and was unable to be contacted after this point. For those participants where values were missing for the penultimate and/or final session, intention-to-treat was assumed and the last known values from either week six or seven as appropriate were carried forward. The participant who only attended the first three sessions was not included in the final analysis. An initial analysis was conducted using only the values available alongside assuming an intention to treat. The analyses produced similar results and so the intention-to-treat added values were included in the final analysis, as this will

provide a more conservative estimate and highlight as potentially more robust, any findings of significance. The total sample therefore consisted of ten participants.

In order to ascertain changes in measures across time (i.e. baseline and outcome scores), analyses consisted of paired samples t-tests, provided assumptions for the use of parametric tests were met (i.e. homogeneity of variance, few/no extreme scores, normal distribution of data). When assumptions were violated the nonparametric alternative, i.e. Wilcoxon matched-pairs signed-rank test, was used. Statistical analyses for the secondary outcome measures were only conducted where both baseline and outcome scores were available for five or more participants in order to improve validity of the results.

Given the exploratory nature of the study and small sample size it was decided not to use Bonferroni-corrected p values to enhance statistical power, despite multiple comparisons, which are known to increase Type-1 error rates (i.e. erroneous rejection of the Null-hypothesis). Due to the potential for insufficient power due to the small sample size, it was decided to raise the α level to 10% to further gain statistical power in order to not miss any interesting results. This may impact on the 95% confidence intervals (CI) calculated and increase the likelihood of zero appearing within the probability range despite a significant result, unless significant below the 5% level. Treatment effect sizes were calculated using Cohen's d statistic (Cohen, 1988), i.e., the difference between the baseline and outcome mean scores was divided by the standard deviation (SD) of the baseline mean. Further analyses on the primary outcome measure (GARS-2) were conducted using a repeated measures ANOVA in order to analyse the learning gains across all eight sessions. Where analyses revealed statistically significant differences, clinical significance analyses were conducted, using the reliable change index derived from published normative data for each measure where this was available (i.e. moving from the 'abnormal' range to the 'normal' range).

Despite the small sample size it was considered worthwhile to explore the data set for trends, comparing the participants by diagnosis and by group attended. The non-parametric Mann-Whitney U test was used due to comparing two small groups, in order to be more conservative in the analysis. Correlations between individual gain scores (for the primary outcome measure) and potential confounding variables were completed in

order to explore possible factors that enabled success, i.e. age, academic functioning and number of sessions attended. The non-parametric Spearman's rank test was used as this is less likely than its parametric equivalent to be affected by the presence of outliers or non-linear relationships more common in small samples. These additional analyses were not conducted on the secondary outcome measures as baseline and outcome scores were not available for all participants due to unreturned questionnaires/drop out rates, resulting in comparisons being made on data for less than ten participants. As directional hypotheses are being tested, all inferential statistics presented are one-tailed unless specified otherwise.

Following on from the group level analysis, individual trajectories were determined in order to check underlying diversity of responses for the primary outcome measure, focusing on areas where significant changes were noted, alongside the individually generated goals. The aim being to determine whether any changes noted was general across all participants, or limited to some and not others. Clinically significant changes were reported for each individual for the primary outcome measure and the reliable change index (RCI) value was calculated to determine whether individual gains were reliable or not. The RCI values were calculated using the reliability coefficients stated in the user manual and the baseline SD scores to determine a group RCI value for each subscale as appropriate.

Finally, a basic thematic analysis was conducted on the evaluation forms completed after the final robot club session. Deductive coding was employed, using the evaluation form questions as the coding framework. Each question therefore formed an existing category from which to draw patterns and develop themes from the responses given. For example, categories included what features the participants and/or their parents liked best or thought worked well about the robot club, alongside what they liked least or thought did not work well. Patterns were drawn from the responses given to each question and used to identify themes common amongst the participants and/or their parents. It is important to note that the responses to each question were often quite brief, making a more systematic and complex analysis impractical. The themes identified are therefore more descriptive as is advised with a small sample size, providing a summary of the information gained.

4. Results

The results of the data analysis will be presented in the following order: (1) results of the whole sample analyses pertaining to the main research hypotheses regarding the effects of the group on selected outcome measures; (2) correlations between individual gain scores and potential confounding variables that could impact on success, i.e., academic functioning and age; (3) results of analysis regarding trends or differences in individual learning curves on selected outcomes; (4) themes from additional analysis pertaining to the completed evaluation forms.

4.1 Group level analysis

4.1.1 Primary outcome measure

Table one presents the group level descriptive statistics for the GARS-2 as measured at each robot club session. Histograms and box plots of the distribution relating to the GARS-2 are shown in appendix F. Exploration for this measure revealed that the assumptions for the use of parametric tests were met.

Sessions	Autism Index Mean (SD)	Stereotyped Behaviours Mean (SD)	Communication Mean (SD)	Social Interaction Mean (SD)
Week 1	92.5 (19.74)	9 (3.2)	8.7 (3.27)	8.9 (3.29)
Week 2	89.2 (16.85)	8.5 (2.27)	8 (2.87)	8.5 (3.31)
Week 3	86.6 (15.37)	8.1 (2.47)	7.9 (2.33)	7.9 (2.85)
Week 4	81.4 (13.76)	7.5 (2.34)	6.7 (1.95)	6.7 (3.62)
Week 5	83.3 (15.71)	7.7 (2.26)	6.9 (2.42)	7.1 (2.01)
Week 6	81.5 (19.65)	7.2 (3.05)	6.7 (3.37)	7 (4.01)
Week 7	80.3 (18.84)	7.3 (2.79)	6.4 (2.95)	7.2 (3.33)
Week 8	82.9 (18.04)	7.8 (2.78)	6.5 (2.95)	7.7 (3.2)

Table One: Mean and standard deviation (SD) scores for the GARS-2 per session (N = 10)

Across the four scales a decrease in rating correlates to an improvement in skills in that domain and reduces the probability of Autism as measured by the GARS-2 (see table two below for the interpretation guide).

Subscale Standard Score	Autism Index	Probability of Autism
7 or higher	85 or higher	Very likely
4 to 6	70 to 84	Possibly
1 to 3	69 or less	Unlikely

Table Two: Interpretation guide for the GARS-2 (Gilliam, 2006)

The calculation of the autism index is dependent on the ratings given for the other three subscales and therefore provides an overall indication of level of skill across these domains. The mean scores suggest an overall improvement in skill over the course of the robot club sessions, as rated by each young person's parent and shows an overall move from the very likely probability of autism category to the possibly category. This suggests a clinically significant change as per the normative data sample. Furthermore, it appears as though most of the improvement occurs in the first four weeks, with no further notable gain occurring in the second half of the robot club sessions (see figure three), suggesting a rapid progress which is generally maintained for the duration of the sessions.
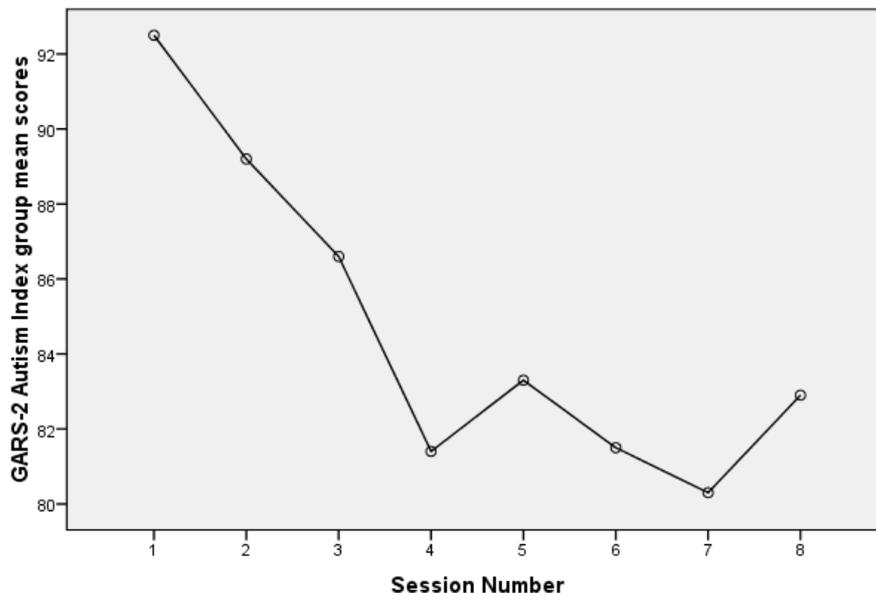
Figure Three: Line graph depicting the group mean scores across sessions for the autism index of the GARS-2 (N = 10)

The baseline and final outcome mean scores were analysed using the paired samples t-test and the results indicate that the week one and week eight scores differed significantly (t(9)=1.768; p=0.056) with an effect size of 0.49 and a 95% confidence interval (CI) of -2.7 to 21.9. A repeated measures ANOVA to analyse the learning gains across all eight sessions revealed a borderline significant result (F(2.47,22.25)=2.33; p=0.11) with a Partial eta squared of 0.21 representing a considerable effect. Repeating paired samples t-tests solely for the first four sessions (t(9)=2.904; p=0.017) and then again for the latter four sessions (t(9)=0.097; p=0.463) verified that the improvements noted occurred across the first four sessions.

The mean scores for the domains of stereotyped behaviour, communication and social interaction all mimic the pattern for the autism index across the eight sessions, suggesting improvements in each domain. Paired samples t-tests revealed that the week one and week eight scores differed significantly for the communication subscale only (t(9)=2.256; p=0.026) with an effect size of 0.67 and a 95% CI of -0.006 to 4.4. This subscale shows a move from the very likely probability of autism category to the possibly category, suggesting a clinically significant change as per the normative data sample. A repeated measures ANOVA for the communication subscale revealed that this improvement was significant across all eight sessions (F(2.72,24.48)=2.77; p=0.068) with a Partial eta squared of 0.24 representing a considerable effect. Repeating paired samples t-tests solely for the first four sessions (t(9)=2.739; p=0.0115) and then again for the latter four sessions (t(9)=0.514; p=0.31) again verified that the improvements noted occurred across the first four sessions.

4.1.2 Secondary outcome measures

Tables four, six and seven presents the group level descriptive statistics for the SSIS, SDQ, behaviour checklist and the CGAS respectively as measured at baseline and at the final robot club session. Mean and SD scores are presented for those participants where both baseline and final outcome values were available and the sample size varies across measures. Box plots of the distribution relating to each of the secondary outcome measures are shown in appendix G. Exploration of each measure revealed that the assumptions for the use of parametric tests were met for all measures with the exception of the social skills subscale of the parent rated SSIS and the CGAS.

<u>SSIS</u>: Scores on the SSIS are interpreted along a scale of what would be expected as average behaviour/ability for a child of the same age (see table three for the interpretation guide). An increase in score on the social skills and academic competence subscales are indicative of an improvement in skills in that domain, i.e. an above average ability in that area. In comparison, an increase in score on the behaviour and autism spectrum subscales, suggests an increase in the number of problem/autistic behaviours observed by the rater. Both baseline and outcome scores were available for five participants (parent rated), two participants (self-rated) and three participants (teacher rated).

Behaviour Level	Score range	Autism spectrum subscale
Well-above average	131-160	-
Above average	116-130	18-45 (T) 15-45 (P)
Average	85-115	4-7 (T) 3-14 (P)
Below average	70-84	0-3 (T) 0-2 (P)
Well-below average	40-69	-

Table Three: Interpretation guide for the SSIS, please note that the guide for the autism spectrum scale is specific for boys age 12 and under as per the sample population. Key = T(teacher rated) P(parent rated) (Gresham & Elliott, 2008)

Outcome measure	Baseline score Mean (SD)	Outcome score Mean (SD)
SSIS - Social skills (parent rated)	79.2 (8.17)	82.2 (10.99)
SSIS - Problem behaviours (parent rated)	138.8 (17.94)	129.4 (17.64)
SSIS - Autism spectrum (parent rated)	23.4 (5.13)	22.4 (5.18)
SSIS - Social skills (self-rated)	90 (4.24)	97.5 (0.71)
SSIS - Problem behaviours (self-rated)	110.5 (3.54)	94.5 (6.36)
SSIS - Social skills (teacher rated)	73.33 (10.6)	75.33 (8.08)
SSIS - Problem behaviours (teacher rated)	110 (32.08)	122 (32.23)
SSIS - Autism spectrum (teacher rated)	26.33 (3.51)	27 (3.61)
SSIS - Academic competence (teacher rated)	89.33 (29.4)	90.67 (28.92)

Table Four: Mean and standard deviation (SD) scores for the SSIS both pre and post intervention (N = 5 parent rated; N = 2 self-rated; N = 3 teacher rated)

The mean scores for the autism spectrum subscale highlight that the participants all exhibit typical autistic behaviours and shows little movement from baseline to outcome

as rated by parents and teachers. The academic competence subscale suggests that the participants are performing in the average range in comparison to their peers and also shows little movement from baseline to outcome.

The young people themselves rate their social skills within the average range and suggest an improvement in skills. Their parents also suggest an improvement in social skills, however these scores all still fall within the below average range. The mean scores for the problem behaviour subscale also suggest an improvement as rated by the young people themselves and their parents, with the parent rated scores falling from the well-above average to the above average range suggesting a clinically significant improvement, although still above the clinical cut off. In comparison, the teacher rated scores suggest little movement in social skill ability and a possible increase in problem behaviours exhibited in the school setting.

The baseline and final outcome mean scores were analysed using the paired samples t-test or the Wilcoxon matched-pairs signed-rank test as appropriate. The analysis revealed that the week one and week eight scores differed significantly for the parent rated social skills subscale (Z=-1.49; p=0.068) with an effect size of 0.37 and a 95% CI of -7.97 to 1.97.

SDQ: For the SDQ a reduction in score across the four negative scales, the total difficulties and impact scores suggests an improvement. In comparison, an increase in score on the positive pro-social scale (PS) is indicative of an improvement (see table five for the interpretation guide). Both baseline and outcome scores were available for five participants (parent rated), three participants (teacher) and two participants (self-rated).

	Normal	Borderline	Abnormal
Parent rated			
Total difficulties	0-13	14-16	17-40
Emotional symptoms	0-3	4	5-10
Conduct problems	0-2	3	4-10
Hyperactivity/inattention	0-5	6	7-10
Peer problems	0-2	3	4-10
Pro-social behaviour	6-10	5	0-4
Teacher rated			
Total difficulties	0-11	12-15	16-40
Emotional symptoms	0-4	5	6-10
Conduct problems	0-2	3	4-10
Hyperactivity/inattention	0-5	6	7-10
Peer problems	0-3	4	5-10
Pro-social behaviour	6-10	5	0-4
Self-rated			
Total difficulties	0-15	16-19	20-40
Emotional symptoms	0-5	6	7-10
Conduct problems	0-3	4	5-10
Hyperactivity/inattention	0-5	6	7-10
Peer problems	0-3	4-5	6-10
Pro-social behaviour	6-10	5	0-4
Impact score	0	1	2 or more

Table Five: Interpretation guide for the SDQ (Goodman, 1997, 1998)

Outcome measure	Baseline score Mean (SD)	Outcome score Mean (SD)
SDQ (Parent rated) - Total (TD)	19.4 (5.51)	16 (3.67)
SDQ (Parent rated) - Emotional symptoms (ES)	4 (2.24)	2.6 (2.07)
SDQ (Parent rated) - Conduct problems (CP)	2.4 (1.52)	2.2 (0.84)
SDQ (Parent rated) - Hyperactivity/inattention (HI)	7.6 (1.14)	7 (1.58)
SDQ (Parent rated) - Peer problems (PR)	5.4 (1.82)	4.2 (1.64)
SDQ (Parent rated) - Pro-social behaviour (PS)	5.2 (1.48)	5.2 (1.92)
SDQ (Parent rated) - Impact	4 (2.16)	3.25 (2.63)
SDQ (Teacher rated) - Total (TD)	19.67 (5.03)	19.67 (3.79)
SDQ (Teacher rated) - Emotional symptoms (ES)	5 (1.73)	4.33 (1.53)
SDQ (Teacher rated) - Conduct problems (CP)	3.33 (2.52)	3.67 (2.08)
SDQ (Teacher rated) - Hyperactivity/inattention (HI)	7.33 (2.08)	8.67 (2.31)
SDQ (Teacher rated) - Peer problems (PR)	4 (1)	3 (1)
SDQ (Teacher rated) - Pro-social behaviour (PS)	6.5 (2.12)	7 (0)
SDQ (Teacher rated) - Impact	5.5 (0.71)	6 (0)
SDQ (Self-rated) - Total (TD)	14 (0)	12.5 (3.54)
SDQ (Self-rated) - Emotional symptoms (ES)	2 (0)	2.5 (2.12)
SDQ (Self-rated) - Conduct problems (CP)	2.5 (0.71)	1 (1.41)
SDQ (Self-rated) - Hyperactivity/inattention (HI)	5.5 (0.71)	6 (1.41)
SDQ (Self-rated) - Peer problems (PR)	4 (0)	3 (1.41)
SDQ (Self-rated) - Pro-social behaviour (PS)	8 (0)	7 (0)
SDQ (Self-rated) - Impact	1.5 (0.71)	0.5 (0.71)

Table Six: Mean and standard deviation (SD) scores for the SDQ both pre and post intervention (N = 5 parent rated; N = 2 self-rated; N = 3 teacher rated)

The parent rated mean scores suggest an improvement in TD, ES, PR and the impact of these difficulties, with no shift in scores on the remaining subscales. Ratings for the ES subscale move from the borderline to the normal range suggesting a clinically significant improvement. The baseline and final outcome mean scores were analysed using the paired samples t-test and the results indicate that the week one and week eight scores differed significantly for the TD ($t(4)=2.01$; $p=0.058$) and PR ($t(4)2.058$; $p=0.055$) subscales only, with effect sizes of 0.62 (95% CI -1.3 to 8.1) and 0.66 (95% CI -0.42 to 2.82) respectively.

The teacher rated mean scores suggest little to no movement from week one to week eight, with some suggestion of a deterioration on the HI subscale. Yet, the scores on the ES and PR subscales both move from the borderline to the normal range suggesting a clinically significant improvement.

The self-rated mean scores are within the normal range with the exception of HI which suggests abnormal difficulties and the impact score, which is suggestive of borderline difficulties. Little movement is noted from base line to outcome, with the exception of a reduction in the impact of such difficulties from borderline to close to within the normal range.

Parent rated behaviour checklist: Baseline and outcome scores were available for five participants. The mean scores for this non-standardised measure suggest little change in the number of observed pro-social behaviours. Yet the number of observed asocial behaviours typical of those with an ASD seems to have decreased, suggesting a reduction in inappropriate social behaviours but with little improvement in appropriate social interaction, which would be indicated by an increase in score. A paired samples t-test revealed that this reduction in asocial behaviour was significantly different from week one to week eight (t(4)2.462; p=0.035) with a large effect size of 2.73 and a 95% CI of -0.82 to 13.62. However, due to this being a non-standardised measure, this effect needs to be considered in conjunction with other findings as no normative data for comparison is available.

Outcome measure	Baseline score Mean (SD)	Outcome score Mean (SD)
Behaviour Checklist - Asocial	42 (2.35)	35.6 (6.99)
Behaviour Checklist - Pro-social	19 (3.54)	20.2 (3.49)
CGAS	50.5 (7.62)	59.5 (6.85)

Table Seven: Mean and standard deviation (SD) scores for the behaviour checklist and CGAS both pre and post intervention (N = 5 behavioural checklist; N = 10 CGAS)

CGAS: An increase in rating on the CGAS is indicative of an improvement in global functioning. Baseline and outcome ratings were available for all ten participants. The mean scores suggest an improvement from week one to week eight, with a move from the 'moderate degree of interference in functioning in most social areas or severe impairment of functioning in one area' category to the 'variable functioning with sporadic difficulties or symptoms in several but not all areas' category (see appendix D.5 for interpretation guide), suggesting a clinically significant improvement. The baseline and final outcome mean scores were analysed using the Wilcoxon matched-pairs signed-

rank test and the results indicate that the week one and week eight scores differed significantly (Z=-2.694; p=0.0035) with an effect size of 1.18 and a 95% CI of -12.39 to -5.79.

4.2 Factors that enable success

In order to correlate the relationship between the primary outcome measure and potential confounding variables, gain scores were calculated for the two domains that showed significant results, the autism index and the communication subscale from the GARS-2, by subtracting the week eight scores from the baseline scores (i.e. gain=baseline-outcome). Three potential confounding variables were identified as factors that could have had an impact on success in the robot club (1) age, (2) academic functioning and (3) total number of sessions attended.

The gain scores were analysed using the non-parametric Spearman's rank test. No evidence was found that improvement on the autism index or the communication subscale of the GARS-2 was correlated with age or with academic functioning using the academic competence subscale from the baseline teacher rated SSIS. Borderline significant results suggest that both the autism index (r_s=0.392; p=0.13) and the communication subscale (r_s=0.388; p=0.13) correlate with the total number of sessions attended, indicating a dosage effect. Scatter plots (see figures four and five) show a general trend suggesting that as the children attend more sessions, they improve more. However this seems to peak at weeks six/seven suggesting that this is not a truly linear relationship.
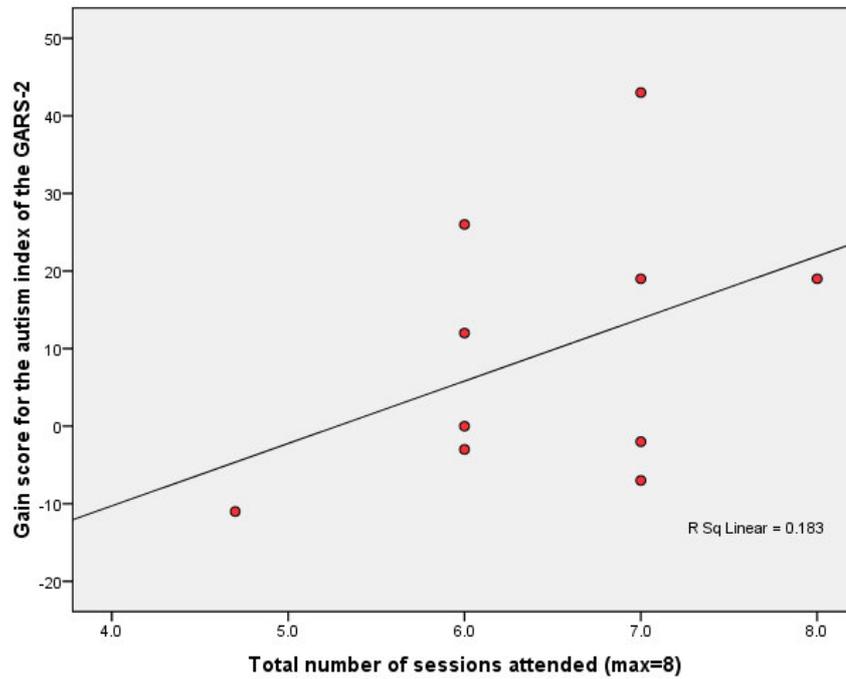
Figure four: Scatter plot depicting the correlation between the gain scores for the autism index (GARS-2) against the total number of sessions attended (N=10)
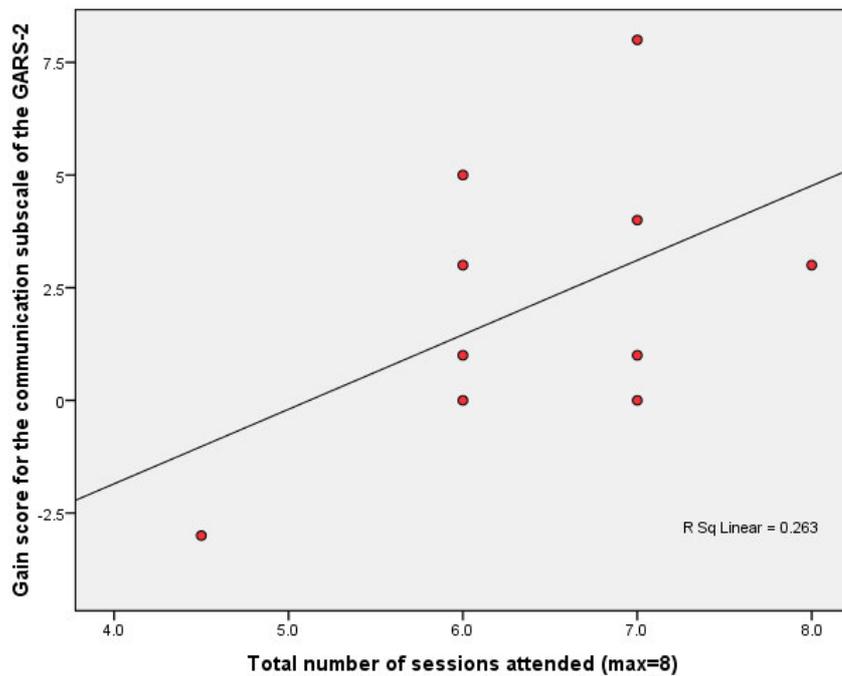
Figure five: Scatter plot depicting the correlation between the gain scores for the communication subscale (GARS-2) against the total number of sessions attended (N=10)

The data set was also explored for trends between groups. The non-parametric Mann-Whitney U test was used to distinguish between diagnoses (see table eight for descriptive statistics relating to the two diagnostic groups) and then group attended i.e. first or second running. Although the mean scores differ slightly, no significant differences were noted between diagnostic group for the autism index (U=10.5; two-tailed exact p=0.762) or communication subscale gain scores (U=10; two-tailed exact p=0.762), which supports the literature suggesting few existing differences between HFA and AS. Neither were there any significant differences noted between group attended (autism index U=7.5; two-tailed exact p=0.310) (communication subscale U=8; two-tailed exact p=0.421). This also suggests that there was no facilitator bias as rated by parents on the GARS-2, or particular benefits for attending either the first or second group ran.

	Total No.	Autism Index Baseline Mean (SD)	Autism Index Outcome Mean (SD)	Communication subscale Baseline Mean (SD)	Communication subscale Outcome Mean (SD)
High-functioning Autism	6	90.83 (10.65)	78.83 (14.47)	8.5 (2.17)	6 (2.68)
Asperger Syndrome	4	95 (31.09)	89 (23.34)	9 (4.9)	7.25 (3.59)

Table Eight: Mean and standard deviation (SD) scores for the autism index and communication subscale for the GARS-2 relating to the two diagnostic groups (N = 10)

4.3 Variation in individual learning curves

Figure six plots the individual learning curves for each participant as rated by the autism index of the GARS-2. With the exception of participants two, seven and nine, the lines suggest improvements occurring (going down over time) across the first four to six weeks, with some evidence of maintenance in the final few sessions. Overall, five participants made considerable improvements (participants one, three, four, eight and ten), four of which were clinically significant (one, three, eight and ten). All bar one of the remaining participants showed little to no movement. The participant where a more pronounced deterioration was noted (an eleven-point increase in rating; participant seven), remained with the very likely category and attended the fewest sessions.

Table nine lists the individual gain scores from baseline to outcome, with a positive score representing an improvement in skill over time and a negative score a deterioration. This does not take into account any fluctuation across the intermediate weeks. The reliable change index (RCI) value was calculated and is also listed alongside whether the gain score represents a clinically significant improvement. All participants who show a clinically significant improvement also indicate a reliable change in the same direction; with the addition of a borderline reliable change for participant four. No participants show a clinically significant deterioration or a reliable change in a negative direction.
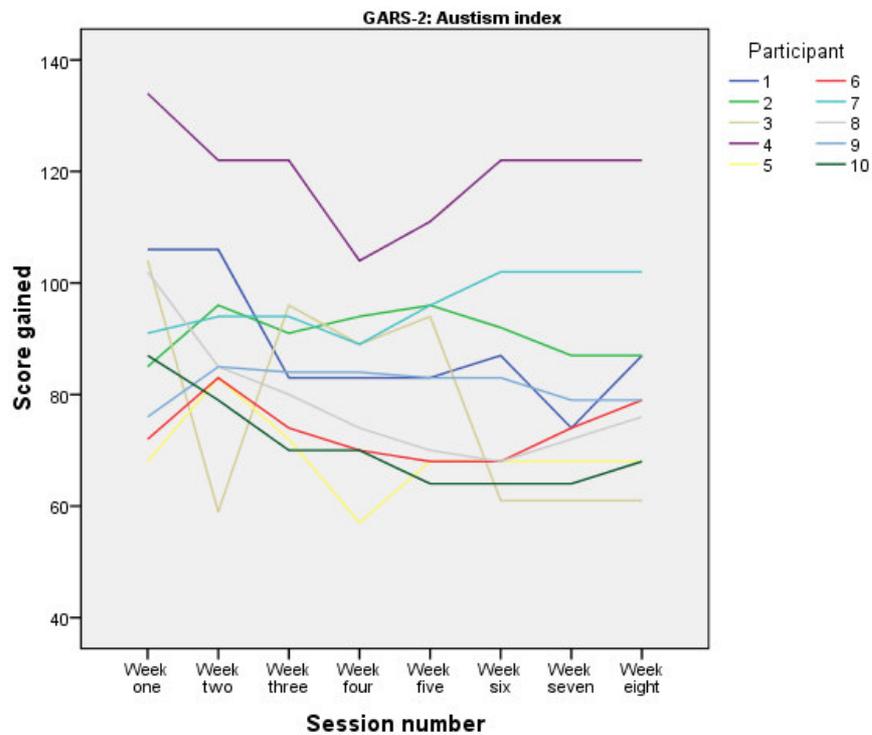
Figure six: Line graph depicting the individual learning curves for each participant on the autism index of the GARS-2 per session (N=10)

Participant Number	Autism Index Gain Score	Reliable Change Index Value	Clinically Significant Improvement
1	19	13.403	✓
2	-2	13.403	-
3	43	13.403	✓
4	12	13.403	-
5	0	13.403	-
6	-7	13.403	-
7	-11	13.403	-
8	26	13.403	✓
9	-3	13.403	-
10	19	13.403	✓

Table Nine: Individual gain scores from baseline to outcome for the autism index of the GARS-2, the corresponding reliable change index (RCI) value and whether the gains were clinically significant (N=10)

The communication subscale follows a similar pattern, with seven participants mimicking the mean trend of improvements over the first four sessions (see figure seven; participants one, three, four, five, six, eight and nine). Of these participants, six maintained an improvement from week one to week eight (participants one, three, four, five, eight and ten), three of which were clinically significant (three, eight and ten). The remaining participants showed unusual curves, with two suggesting no change (one with fluctuation across the sessions) (participants two and nine). The final and only participant to suggest deterioration remained within the very likely category and again was the participant to attend the fewest sessions (participant seven).

Table ten lists the individual gain scores from baseline to outcome, alongside the RCI value and whether the gain score represents a clinically significant improvement. All participants who show a clinically significant improvement also indicate a reliable change in the same direction; with the addition of a borderline reliable change for participants one and four. No participants show a clinically significant deterioration, however one participant shows a borderline reliable change suggesting deterioration (participant seven).

GARS-2: Communication subscale
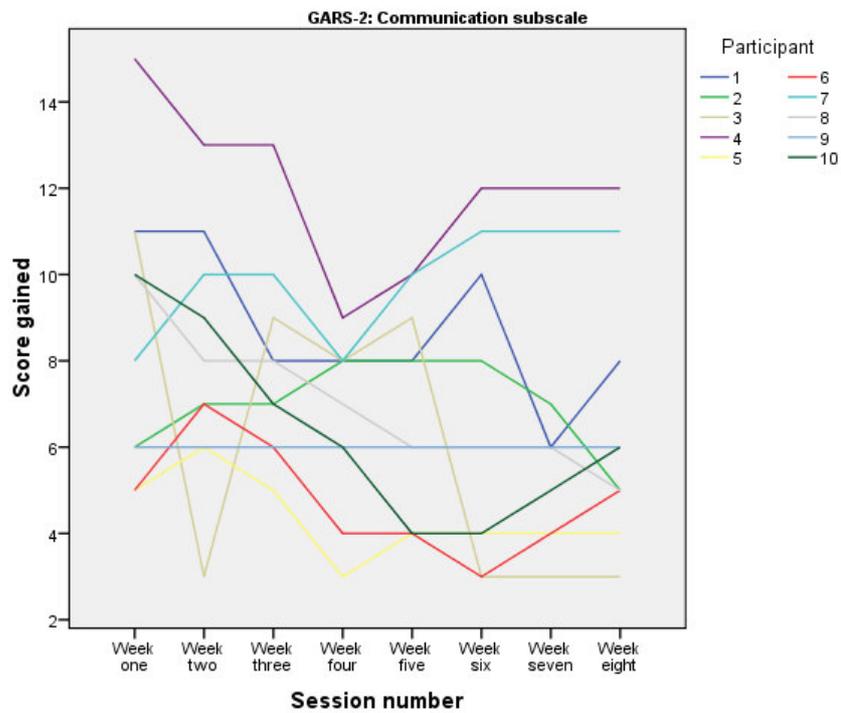
Figure seven: Line graph depicting the individual learning curves for each participant on the communication subscale of the GARS-2 per session (N=10)

Participant Number	Communication Subscale Gain Score	Reliable Change Index Value	Clinically Significant Improvement
1	3	3.412	-
2	1	3.412	-
3	8	3.412	✓
4	3	3.412	-
5	1	3.412	-
6	0	3.412	-
7	-3	3.412	-
8	5	3.412	✓
9	0	3.412	-
10	4	3.412	✓

Table Ten: Individual gain scores from baseline to outcome for the communication subscale of the GARS-2, the corresponding reliable change index (RCI) value and whether the gains were clinically significant (N=10)

In addition to the weekly parent ratings on the GARS-2, each participant rated their individually selected goals based on how close they felt they were to achieving their goal

that week. The number of goals selected ranged from four to seven, averaging at between five and six goals per participant. Many of the young people selected difficulties typical of ASDs as goals for attending the robot club, with other goals focussed around friendships and interacting with peers (see table eleven for a list of all goals identified).

For the majority of participants, ratings seem to fluctuate each session, with a general move towards perceived improvement (see appendix H for line graphs relating to each participants goal ratings). Their ratings do not suggest a naturally smooth progression towards achieving one's goals, but rather an oscillating process that varies week to week depending on one's experiences at that time, i.e., some goals/participants have smoother lines than other. Not all goals are achieved by all participants but the trend does appear to be for improvements from week one to week eight, despite fluctuation during weeks two-to-seven. Nor does the order in which goals are identified seem to have influenced the positioning of the first or last rating in comparison to the other goals identified by each participant. Due to the small sample size, coupled with the fact that each numbered goal is unique to each participant, statistical analysis could not be conducted to determine if ratings for each goal increased over the eight sessions for the whole sample, nor if order identified influenced outcome.

Goal: To be better at…	Number of participants that identified goal
Making conversations, staying on topic, not interrupting	7
Aim to make friends, talk more to others	6
Controlling emotions (anger, excitement, relaxed)	6
Staying focussed / not getting distracted	6
Using listening skills	5
Taking turns	5
Saying if I am bored / unhappy, ask if am stuck	4
Sharing, teamwork	3
Talking at the right volume	2
Following instructions	2
Leading or going first	2
Trying something new	2
Making eye contact	2
Following changes in plans	1
Being aware of others personal space	1

Table Eleven: List of goals identified and by how many participants

4.4 Additional themes

Evaluation forms were completed and returned by seven of the young people and five of the parents. For the majority of questions asked, common themes were identifiable suggesting a consensus of responses.

Many made reference to the <u>topic of robotics</u> as a highlight of attending the group, suggesting that this was a useful and engaging subject matter, through expressing enjoyment about programming the robots, gaining mastery over the tasks and an existing interest in robots and computers. In addition, the parents highlighted factors pertaining to the <u>organisation</u> of the sessions alongside providing a setting to <u>practise social skills</u> and working with peers.

"(I liked) making the robots work (best)"

"I know a lot about robots already so I found it easy"

"Well organised…with a very calm atmosphere"

"Good opportunity to work with peers and practice social skills"

All stated that they would recommend the robot club to others with similar difficulties, with the parents citing the <u>topic</u>, <u>socialising</u> components and opportunities to <u>practice social skills</u> in a constructive way as reasons.

"It's a great place to practice attention, listening, cooperation/social skills"

"Can use the club to socialise with others with a similar interest in robotics"

In reference to what they had liked least about attending/what had worked less well, many made reference to the <u>disruption</u> caused by individual children interrupting the learning opportunities for the others.

"The ability of some children to disrupt the entire class"

"Another child who was very annoying"

"When kids muck around"

When asked what advice they would give if the robot club was to continue, the responses from the young people fell into two themes. Many suggested increasing the level of complexity with regards to robotics, including using different robots, with more advanced programming being taught. Secondly, reference was made to being helpful and nice to all those present in the group. It was unclear if the latter was directed at the group facilitators and/or the other young people.

"More advance robots and different ones"

"Be nice to everyone"

The parent's responses were much more diverse with no common themes across evaluation forms. Advice included a more detailed behavioural structure for managing disruption, further consideration to how instructions were given to ensure all levels of understanding, splitting the group by ability, using fewer questionnaires and no advice given.

Finally, they were asked how they/their child found working with others and if anything had been learnt about working in groups since attending the robot club. The main focus of responses for the young people, related to the ease experienced at working with some children but not others. Many explained that they had learnt that they could enjoy working with others, but that this had depended on who it was. The parents highlighted improvements that they had noticed in their children at working in a group setting, particularly with other children as opposed to adults. There were also some references made to social rules/strategies, for example, learning to ignore others rather than reacting, and highlighting for parents what skills their child needed further help to develop.

"I worked with some people better than others"

"Depends on who it was, (I) found it easier to work with some people than others"

"XX has seriously improved his ability to work in a group setting"

"He is very interested in robotics and has learnt new skills on how to interact with other children"

"Has tried to ignore others who are behaving inappropriately"

5. Discussion

The primary aim of this study was to assess the impact of using a non-humanoid robot to promote social engagement in a group of young people with either HFA or AS. The main objective was to provide a natural environment that relies on systemising to provide the social pressure for task solution; thus engaging these young people in a social setting, through which more appropriate social and communication skills could be developed and better generalised to other settings. This study aimed to explore the means through which this intervention exerted its effects through specific outcome measures.

To address these aims, this section will begun by presenting a summary and discussion of the main findings, both for the whole group analysis and individual trajectories. The interpretation of these findings will also include consideration of the themes identified through the completed evaluation forms. Implications of the findings in relation to available research and theories will be presented, followed by a discussion of the clinical implications. Strengths and limitations of the study will be presented, along with suggestions for future research before providing some concluding comments.

5.1 Summary of main findings

5.1.1 Primary outcome measure

Analysis of the whole sample revealed statistically and clinically significant improvements on a general autism index scale and in communication skills specifically, as measured by the GARS-2. Although the mean scores for the stereotyped behaviours and social interaction subscales also suggested improvements, these were not found to be significantly different. On the autism index scale, improvements of half a standard deviation (SD) were made, compared to approximately two thirds of a SD on the communication subscale. The overall progress suggested a rapid improvement over the first four sessions of the robot club, with no further gains made throughout the remaining four sessions. This pattern was verified through statistical calculations.

The majority of individual participants were found to follow this pattern, although the level of change varied. Deterioration for individual participants was minimal with the exception of one participant who struggled most in the group setting. However this was not a clinically significant deterioration, which suggests that attendance at the robot club was

not detrimental. It is important to note that additional information was supplied for this young person by their teacher through the completed SDQ.

"(XX is) more aware of differences between himself and his peers,(he) now refers to himself as autistic and feels his peers cannot relate to him as they do not understand his way of thinking"

This suggests that this individual participant was in the process of developing a new understanding of himself as an individual and as autistic which was affecting how he relates to other children in the school setting. This could have impacted on his ability to make the most out of attendance at the robot club and have influenced the difficulties he had in attending sessions. This perhaps might indicate the usefulness of including some discursive components in the group regarding what it means to be on the autistic spectrum and how the young people cope and manage with this. For the remaining participants however, the mean pattern of improvement was predominantly substantiated.

These improvements were found to not be affected by age of participant, or by their academic functioning as rated by their teachers in comparison to their peers. Diagnosis and group attended were also found to show no significant differences between groups. However, the number of sessions attended was found to impact on both the autism index and communication subscale gain scores, suggesting a trend of greater improvements made when the number of sessions attended increased. This was not however, a truly linear relationship.

The rapid progress noted over the first four sessions suggests that the total number of sessions offered could be reduced, without impacting on gain scores. However, the relationship between number of sessions attended and level of change implies that only attending four sessions might not have resulted in the same level of improvements. It is possible that the additional sessions worked to maintain the initial improvements. However, no follow up data is available to determine whether these improvements were maintained post completion of the robot club. It is also possible that this relationship represents individual differences in learning and that the number of sessions needed to reveal the same level of improvement might differ per person. Despite this, the general

trend suggests a pattern of improvement that fit for the majority of those who participated in this study. A reduction in the number of session offered, might therefore suit the majority of young people.

It is interesting that the greatest improvements were reported in the domain of communication. This subscale describes verbal and non-verbal behaviours that are symptomatic of autism (Gilliam, 2006). For example, repeating words or phrases over and over; looking away or avoiding looking at the speaker when name is called; using pronouns inappropriately; repeating unintelligible sounds; and speaking or signing with a flat tone/affect. It is possible that parents have more contact with their children using this domain of interaction, and were therefore more aware of changes in skill. Stereotyped behaviours often cause the most distress and disruption in family life and can therefore be very apparent and increase anxiety for parents, possibly resulting in overall higher ratings. Within the group setting, it is possible that the specific pressures on the communication required were especially essential to successfully solve the robotic tasks. It is also important to consider the potential of bias in reporting, whereby parents may be more inclined to notice and report difficulties/improvements dependent on what their expectations were from attendance at the robot club.

5.1.2 Secondary outcome measures

All secondary outcome measures were completed to provide baseline and final outcome scores from a variety of sources. Analysis on the whole sample revealed improvements as rated by parents and the young people themselves, some of which were statistically and clinically significant. However, these changes were not repeated in the teacher rated measures, suggesting little impact on the school environment. It may also be that busy teachers with multiple students to observe, may not have noticed any possible changes made.

The autism specific measure, the SSIS, suggested significant improvements in social skills (parent and self-rated) and a significant reduction in problem behaviours (self-rated). The behaviour screening measure, the SDQ, suggested significant improvements in overall difficulties and peer relationships (both parent rated), and in conduct problems (self-rated), but a deterioration in hyperactivity and inattention in the school setting (teacher rated). A reduction in the number of asocial behaviours observed was also

reported as significant on the non-standardised autism specific behavioural checklist. The robot club facilitator rated measure, the CGAS, suggested a significant improvement on overall level of functioning, as observed during the robot club sessions.

Overall, these results suggest a greater consistency between parent and self-rated measures, in comparison to those rated by a teacher. Coupled with the highly significant CGAS scores, this suggests improvements were noted within the robot club setting and in the home environment, but that these were perhaps not generalised to educational settings. Despite the sessions being held in a school environment, it is possible that the content of the sessions needs to be considered further, in order to make it more relevant to this setting and foster better generalisation of skills. It is also important to remember that the return rate for teacher completed outcome measures was low, which would have impacted on the ability to detect significant results. The mean scores presented are therefore not representative of the whole sample. It is again also important to consider the potential for bias in reporting, whereby teachers may be more inclined to notice and report difficulties in order to highlight problems and encourage appropriate support being put into place.

The school environment is likely to also require socialising and learning in larger group settings, which could increase anxiety, thus increasing stereotyped behaviours and ability to concentrate and remain on task (see Howlin, 1998b). Furthermore, it may also be that children with ASDs struggle particularly in social-communication interaction with neuro-typical children and the possibility of including such children as models and facilitators to assist generalisation may also be worth considering.

5.1.3 Additional analyses

The individually identified goal based outcomes suggested some variation in achievement. Some participants exhibited smoother lines regarding their weekly ratings; however the norm seemed to be for fluctuating ratings, resulting in an overall improvement by the final session. Not all goals were reported to be achieved, but the trend does appear to be for improvements from week one to week eight, despite fluctuation during weeks two-to-seven.

Although each young person was supported to develop their own goals, there did appear to be an overlap, with many selecting goals around similar themes. Many of the young people aimed to improve their conversation skills and hoped to make friends within the group. A desire to be able to stay focussed on the topic, alongside having more control over reactive emotions also featured highly, which suggests that these are the areas that these young people struggle with the most. They are interestingly also the areas highlighted by the teachers on the SDQ as the most problematic in the school environment. There were also some highly specific goals selected, such as feeling more confident to lead, or volunteer to go first, as well as to be more aware of other people's personal space. Often these appeared to be things that highly distressed the young person, as they appeared to desperately desire to be able to get this right.

Due to the small sample size and the different goals selected by each participant, it is difficult to determine more than observed patterns in the data collected. However, due to the highly individual nature of this form of outcome measure, it could possibly be used in other settings, in conjunction with standardised measures, to develop individual support plans for each child. For research purposes, a larger sample size would have enabled more advanced statistics to be undertaken and would have allowed the analysis to have been developed further. This may also have led to increased findings of significance, given smaller numbers generally mean less statistical power.

Themes from the completed evaluation forms highlighted the acceptability of the topic of robotics as a way to engage young people on the autistic spectrum, which is consistent with current literature. The young people were keen for more advanced robotics, alternative robots and more complex programming. Parents made reference to opportunities for general socialising, alongside the opportunity to practice specific social skills, implying that this is not generally possible in typical social settings. This highlights the need to provide particular environments to better foster social and communication skills in young people on the autistic spectrum.

Both the young people and their parents were very conscious of individual children causing disruption to the whole group, particularly in the early stages on the robot club, as each young person settled. The hyper-systemising nature of autism implies the need for structure and predictability. More explicit instructions to the young people regarding

appropriate behaviour and consequences for inappropriate behaviour may have supported this. Pre-group assessment meetings to meet other participants informally and/or seeing the exact setting and robots in advance may also aid quicker 'settling'.

Despite any disruption caused, a valuable lesson appears to have been learnt. Many of the young people explained that they had worked well with some children but struggled to work with others. This is a common human experience for all children and adults, with personal experience of knowing that you can't always get on with everyone. This is therefore an important lesson to learn. This had been difficult at times for the young people to manage in the group setting, but some of them explained that they had learnt that it could be actually be fun or enjoyable to work with peers, which seemed to be a new experience for them.

5.2 Implications for theory

No formal testing of the hyper-systemising theory was conducted during this study. The ability to systemise was assumed and alongside findings from previous research, was used to develop aims and hypotheses to be tested through providing a unique environment. However, implications for theory can still be inferred from the analysis. The hyper-systemising theory proposes that young people with an ASD will be drawn to focussing on 'toys' that follow systematic rules. The topic of robotics proved an engaging 'toy' that sustained the interest of all participants during the sessions and seemed to provide a focus of shared attention. Parents highlighted this as a topic of existing interest for some of their children and felt that it provided a useful and constructive setting to practice social skills.

Previous research into social skills training groups suggested that social engagement and naturalistic settings play an important role in improving the ability to generalise the skills learnt. No formal social skills training took place during the current study, yet the results revealed improvements in social and communication skills on specific outcome measures. This suggests a naturalistic and implicit learning of these skills, which links to theories of learned behaviour and a natural development of empathising skills, such as ToM, in typically developing children. The implication of the hyper-systemising theory being that no specific social skills teaching is necessary if a suitable environment is

provided to foster a natural development of skills, i.e., an environment that relies on systemising.

The finding that the young people who attended the robot club demonstrated significant improvements in the domain of communication, but not stereotyped behaviour as rated on the GARS-2, could fit with the hypothesis that the obsessional / stereotyped behaviours often observed, are not reciprocally linked to empathising, but more involved with systemising behaviour, as explained by the hyper-systemising theory.

The ratings reported by the CGAS scores imply global improvements, however these ratings were given based on observations during the robot club sessions and therefore only highlight improvements noticed within that setting; perhaps failing to generalise fully. This therefore fits with the limited reduction in problem behaviours being reported outside of the group but significant improvements in communication and pro-social behaviours being generalised to the home setting, but not the school environment.

5.3 Clinical implications of the study

Based on the findings, some implications for clinical practise are presented. This study provides support for the use of robots as a tool for engaging high-functioning young people on the autistic spectrum in social engagement and suggests that through engagement in such an implicit social environment, that improved social and communication skills can be fostered and generalised to certain settings. This may be useful information for the practicing clinician and/or educational professional involved in engaging young people with HFA or AS, particularly in a group setting. Involvement of computers and/or non-humanoid robots alongside human contact, could enhance a child's desire to participate and provide a setting in which they can better develop appropriate communication skills. For young people who are difficult to engage, this could act as a 'way in', or serve to provide a focus of shared attention.

This study also provides implications for learning, as the aim was not to actively teach specific social skills, but rather to foster a natural development of skill through experience. This implies that technology and robotics could be used at a more basic level, not requiring specific skills to be targeted by professionals (or parents/carers). For example, consideration could be taken for what toys are available in clinic and waiting

room settings, i.e., a GP surgery or Paediatrician's clinic. However, the priority would be to engage the young person in play, rather than rely on their own interest in a particular toy or pastime to keep them occupied. The key seems to be social engagement in a natural setting, although natural for someone on the autistic spectrum.

In therapeutic settings, robots could be used to engage a young person on the autistic spectrum. Although not implied through this study, this might be a suitable way of engaging younger children or less verbal children, where talking therapies would be more difficult, on an individual basis in a play therapy setting. For those higher functioning individuals, this study suggests that services might consider running similar groups, or supporting voluntary agencies to develop more appropriate natural settings using robots and technology to foster social engagement.

This study adds to the existing literature regarding the usefulness of technology and robotics in working with individuals on the autistic spectrum. In terms of high-functioning individuals, this study is one of the first to report improvements for this clinical group and to provide quantitative data relating to specific patterns of improvement and effect sizes. This will provide useful information in developing further studies and in considering what clinical services to offer this population. It adds to the accumulating evidence that suggests that technology is an appropriate medium to engage young people with an ASD and that this clinical group often express an interest in the topic of robotics and are willing to engage in social interaction with others around this topic.

5.4 Strengths and limitations of the study

Strengths of research

Volume of data: Despite a small sample size and gaps in the data set, a large amount of data was available for each child. This has enabled both group and individual level analyses to be conducted alongside presenting some qualitative data, thus providing a rich variety of information to inform the findings, from a variety of sources. In comparison to existing research, weekly gains were able to be established alongside pre and post comparisons. This enabled a pattern of improvement to be determined, which adds useful information to the way this type of intervention exerts its affects.

Autism specific outcome measures: An additional strength of the study was the use of autism specific outcome measures. Much of the existing research in the field of robotics and autism has presented narrative accounts of suspected improvements; relying on behavioural observations of real time social interactions, without providing evidence of generalisation of skill. The use of additional quantitative measures in this study has enabled rating scales validated for autistic populations, alongside more generic scales, to be used to build a picture of the specific areas found to be targeted by attendance at the robot club.

External validity: The findings from this study can be generalised to an extent to both the wider HFA and AS population, particularly as no statistical differences were found between participants with each diagnosis. Whilst the presence of potential co-morbid conditions affects the confidence with which one can draw statistical conclusions, the heterogeneity of this clinical group is perhaps more representative than if there had been no co-morbidities present. The study is also ecologically representative in terms of the setting in which the intervention took place. The robot club was held in a school setting, as part of an after school club, with all participants familiar with the surroundings.

Recent research estimates that children with autism show a gender ratio of 4:1 (male to female) across the full IQ range (Manning, Baron-Cohen, Wheelwright & Sanders, 2001). However, all participants for this study were male, which suggests that it is not fully representative of the high-functioning autistic population. The hyper-systemising theory distinguishes between cognitive styles that typically occur in men or women, but does not distinguish between genders within autism. It would be interesting to consider whether girls on the spectrum would be as interested in robots and whether typical gender stereotypes would be evident in strong systemisers (S>>E or Extreme Type S).

Limitations of research

Small sample size: One significant limitation of this study was the small sample size. This serves to reduce the statistical power and decrease the chance of statistically significant results being detected. In order to enhance power, it was decided to increase the alpha level to 10% and not apply Bonferroni corrected p-values. The latter can be particularly problematic due to multiple comparisons, which are known to increase the probability of Type-1 errors. However, re-running a power analysis with an alpha error of

10% (one-tailed) revealed that a sample size of 8 would be sufficient to detect a strong effect size (assumption based on previous research) with a power of 0.8 (see figure eight).

The sample of ten participants was therefore acceptable and by increasing the alpha level, improved the chances of detecting significant results if present. The data set was further strengthened through inserting interpolation values and assuming intention to treat where necessary for the primary outcome measure. This provided a complete data set, further strengthening the implications that can be drawn from the analysis, as they are based on a more conservative estimate of significance. Despite these precautions, many gaps in the data set were present for the secondary outcome measures and therefore analyses were conducted on limited data availability. This is particularly relevant for all teacher and self-rated outcome measures and therefore these findings have to be considered tentatively.

T tests - Means: Difference between two dependent means (matched pairs)
Analysis: A priori: Compute required sample size

Input: Tail(s) =   One
                Effect size dz =   0.80
                α err prob =   0.10
                Power (1-β err prob) = 0.8

Output: Noncentrality parameter δ = 2.2627417
                Critical t =   1.4149239
                Df =   7
                Total sample size =   8
                Actual power =   0.8000760

Figure Eight: Additional prior power analysis output from GPower3

Lack of a comparison group: An additional problem relates to the use of primarily within-group comparisons to explore the mechanisms through which the current intervention exerts its effects. In order to draw firm conclusions as to whether the improvements reported are as a direct result of attendance at the robot club, it would seem important to adopt a randomized control trial (RCT) design with an alternative intervention option. This could include individuals from the same clinical population attending an alternative therapeutic group setting, a similarly non-therapeutic group setting without the inclusion

of robots to account for the non-specifics of the intervention and/or no attendance at any group intervention.

A comparative control group had been included as part of this study's design, unfortunately the lead researcher encountered no success recruiting for this group, possibly due to issues of motivation. Future research could consider potential incentives to facilitate recruitment to comparison groups. Alternatively, a waiting list control group could be used, with an opportunity to attend an additional running of the intervention at a later date.

Lack of follow up: The current study only reports post-intervention findings measured immediately after completion of the group. It is not known whether the generalisability of the improvements reported have been maintained beyond the eight session format. This would thus appear to be an important improvement to the current study, particularly in light of the difficulties associated with being on the autistic spectrum affecting individuals throughout their lifespan.

Co-morbid conditions: Some of the participants had additional secondary diagnoses of behavioural disorders and/or specific learning difficulties which were not recorded as part of this study. This would suggest that the sample population may not have been a completely homogeneous group. However this is more representative of the general autistic population, as the presence of co-morbid difficulties are well documented (see Atwood, 2007; Howlin, 1998b). Nonetheless, this could have been interesting to record and subsequently consider as a potential confounding variable.

5.5 Suggestions for future research

The current study has highlighted areas for improvements which could be addressed in further studies, as well as areas in the literature which could be explored further. Some ideas for regarding how improvements might be achieved have already be presented along with limitations of the study and will only be mentioned briefly.

In relation to this study specifically, video data is available for coding in order to provide additional information regarding the real time social interactions observed during the robot club sessions. This form of analysis could provide useful information regarding

specific changes to individual skill and strategies employed by the young people, and interpreted in conjunction with the quantitative data presented here.

The findings from the current study would benefit from additional data from larger sample sizes, in order to improve the return rate of completed questionnaires and to further strengthen any significant findings and interpretations made from the analysis. The number of sessions offered should be also considered in view of the pattern of improvements reported. Inclusion of comparative groups would further strengthen the ethics of participation and enable further conclusions to be drawn as to the specific effects of this type of intervention. Collecting follow up data would enable levels of maintenance of skills to be measured and would better reflect whether the improvements recorded were maintained post completion of the group.

In light of the variation noted between some of the participants, further consideration could be given to potential confounding variables. Possibly a more rigorous measure of intellectual ability and a larger sample size might capture greater variation in educational settings or past experience of attending groups/clubs both with typically developing peers and/or other young people on the autistic spectrum. Previous experience of after school groups/clubs could affect how confident each individual feels in this type of setting and how engaging in this form of activity fits into their existing routine. This in turn could influence their level of engagement and/or exhibition of stereotyped and problem behaviours due to stress.

Further exploration as to why the improvements noted did not generalise to the school setting would also be important, as young people spend the majority of their time in educational environments. For example, changes to the session content could be considered to include more school relevant situations along the lines of the studies employing virtual reality to practice real life situations. However, the hyper-systemising theory might suggest that it is the environment that needs to be altered to better mimic a systemisable school setting, i.e., number and 'type' of young people present in each group. Therefore it may be worth considering whether the inclusion of neuro-typical school peers along similar lines to the school-based studies mentioned in chapter two, may perhaps help to increase the ecological validity of the study and possibly assist with the generalisation of learned skills to school settings.

It would also be interesting to consider the implications of different types of robots being used. This study used a non-humanoid robot; future studies could possibly consider alternative robots as comparison groups, such as the humanoid robot KASPAR (Kinesics and Synchronisation in Personal Assistant Robotics).

5.6 Conclusions

This study showed that robots could be used to engage a group of young people with either HFA or AS, and that better social and communication skills could be developed through implicit social learning in this setting. Some statistically and clinically significant improvements were reported, suggesting that this is a useful intervention worthy of further exploration. Strengths of the study included the volume of data available, the autism specific measures employed and the use of relatively naturalistic settings. In addition, this is one of the first studies to report improvements for this clinical group and to provide quantitative data relating to specific patterns of improvement and effect sizes. However, the study did have limitations, which will affect the strength of some of the conclusions that can be drawn.

Despite this, the study provides useful information for developing further studies and in considering what clinical services might be useful to offer this population. It adds to the accumulating evidence that suggests that technology is an appropriate medium to engage young people with an ASD and that this clinical group often express an interest in the topic of robotics and are accordingly willing and able to engage in social interaction with other young people around this topic.

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7. Appendices

Appendix A: Parent and teacher information sheet

THE ROBOT CLUB

INFORMATION SHEET FOR PARENTS AND TEACHERS

Introduction
I am excited to be involved in re-running the SNAAP Robot Club, which supplements the SNAAP multimedia club with a weekly course designed both to teach children about robotics, as well as study whether robots can act as social mediators to support the development of social skills. Specifically, the children will learn how to program Lego Mindstorms NXT robots and how to make them interact and work together in the real world. While the children are programming their robots and making them collaborate with the other children's robots, we will observe whether cooperation and socialization among the children is linked with collaboration among their robots. Before you decide whether you would like to give consent for your child to attend the club, please take the time to read the following information, which I have written to help you understand why the study is being carried out and what it will involve.

The researchers
The study is being carried out by Sarah Blank, Trainee Clinical Psychologist, as part of a Doctoral qualification in Clinical Psychology at the University of Hertfordshire. The study is supervised by Dr Nick Wood, Research Tutor and Clinical Psychologist and Dr Ben Robins, Senior Research Fellow. Josh Wainer who ran the previous Robot Club will also be involved.

What is the purpose of the study?
This study is interested in whether robots can act as mediators to support the development of social skills in young people with autism. We are particularly interested in whether the robots can be used in group settings, as it is in groups that young people with autism often feel most out of their depth. As I am sure you know, young people with high-functioning autism and/or Asperger's syndrome are often highly motivated to interact in social settings, but are often very nervous and unsure of the 'correct' way of doing things. By supporting these young people to feel more confident in social situations, we hope to give them tools they can use as they go through adolescence and into adulthood. It is hoped that through such research, that the use of robots can be developed further to better help more young people with autism.

What is involved?
If you decide that your family will take part, your child will be able to join the club along with other children and learn more about robotics. As we are interested in whether the robots can help facilitate the development of better social skills, it will be necessary for

you and your child to complete some short questionnaires looking at different aspects of their social skills, behaviour and self-esteem, as well as rating how close they are to achieving some individual goals that the children pick for themselves. You would need to complete these questionnaires at the beginning and end of the overall programme, a period of 9-weeks, as well as answer some short questions at the end of each weekly session in order to best monitor how the group is impacting on your child's social skills. It may also be helpful for teachers to complete some of the questionnaires, also at the beginning and end of the programme, in order to see if they have noticed any changes whilst your child is in school. It is anticipated that the answers to all these questionnaires will enable us to monitor any improvements and/or changes as the club progresses. We are also hoping to be able to meet with you again approximately two months after the club has finished in order to again complete the questionnaires to see what changes have been maintained.

With the support of the SNAAP administrators, we will be running the Robot Club at North Finchley Catholic High School in similar rooms to the ones that SNAAP is usually held in. We will be running two one-hour sessions and your child will take part in one of these sessions each week for 9 weeks. This will allow as many children as possible to attend. During these sessions in groups of two-to-three, the children will learn to program the robots and make the robots interact in a specially built arena. As a parent, you will be able to stay and watch the club and chat to other parents. However, it is important that your child is allowed to find their own way in the group and learn without your help.

The sessions will be videotaped and this will provide a valuable contribution to ongoing research in this area. This is vital to the development of the robots as better aids for the children's education and social development. By videoing the sessions, we can re-watch them in order to make sure that we don't miss anything important whilst the sessions are going on. Each session will be fully supervised and safety factors will be carefully considered with the SNAAP administrators. The project has the approval of the University of Hertfordshire Ethics Committee.

Who can take part?
Any family who are members of SNAAP are able to participate. All we ask is that your son/daughter has a diagnosis of either high-functioning autism or Asperger's syndrome so they can make the most out of the group as possible. If you are unsure, please do not hesitate to contact either myself or one of the SNAAP administrators. We hope that 6-to-7 children will be attending each hourly session.

Do I have to take part?
No. If you do not want your family to take part, or you change your mind *at any time* during your participation in this study, you do not need to give a reason. Participation is entirely voluntary and you can withdraw at any time.

If you are interested in your child attending 'The Robot Club' please let the SNAAP administrators know. They will be able to pass your name on to me so we can arrange to meet before the club is due to start, or if you wish, please contact me directly. This will enable you to ask any questions you may have before deciding if you would like participate in the study. If you do decide to participate, I would ask you to complete the consent form below.

Please be aware that any information collected through the course of the study, or during the club meetings will remain confidential and will only be used for this study. No information about your child or your family will be passed on, nor will it be identifiable when the results of the study are written up. The only exception to this is if anything is seen or heard that worries us so much that we feel it is important that someone else is made aware. If this situation did occur we would discuss this with you in the first instance so we could agree on the appropriate action and who else needed to be informed. All information collected will be kept in a locked cabinet in the SNAAP rooms / at the university and will be destroyed after the study is completed; this refers to all written and videoed material unless anonymised. You will be able to ask questions about the data collected at any time during the study.

If you are interested in this study but are not sure about actually attending the 'Robot Club', I am also interested in families forming a control group so I can compare the answers given on the questionnaires by those attending the club, to those who don't. If you and your family decide to take part in the control group you would need to complete the questionnaires at the beginning and end of the overall programme, but would not actually attend the club itself. As mentioned above, all information would be kept confidential unless something that was particularly worrying was discussed, in which case we would first discuss this with you and if necessary seek agreement to inform an appropriate other person.

If you have any further queries, please do not hesitate to contact me on:
S.T.Blank@herts.ac.uk

Thank you for your support and I look forward to meeting you soon,
Sarah Blank

Appendix B: Consent form

CONSENT FORM: THE ROBOT CLUB

Please tick as appropriate

I confirm that I have read and understand the information sheet for 'The Robot Club' study. I have had the opportunity to consider the information and if needed ask questions that were satisfactorily answered. ☐

I understand that participation is voluntary and that I am free to withdraw at any time, without giving any reason. ☐

I understand that the information that I will submit will be confidential, and used only for this study. ☐

I understand that if anything extremely worrying is disclosed, that it may be necessary to break this confidentiality for my family's safety. I understand that this will be discussed with me first and appropriate action taken. ☐

I have read all the information provided and I give my full consent for my family to take part in the study and for my child to attend the SNAAP Robot Club at North Finchley School, including the video recording of the sessions. ☐

I also agree that any stills and/or video sequences from the club may be used for scientific publication or presentation about the project within the scientific community. Not consenting does not affect you chance to participate and attend the club. ☐

I have read all the information provided and I give my full consent for my family to take part in the study and to join the control group. I understand that this means that my child will not be attending the Robot Club, but that if it is found to be effective we will be informed and considered for future groups. ☐

If you have indicated that you would like your family to participate in this study and either attend 'The Robot Club' or join the control group please sign and date below.

....
Name of parent/carer   Date   Signature

....
Name of young person (if able)   Date   Signature

Appendix C: Robot Club session slides adapted for this study from those designed for use in Wainer et al (2008) exploratory study (not for copying without permission from the author(s))

Robot Club

Week 1

Group Name

Group Rules

What will I do?

The Direction Game

What can the robots do?

Programming the robots

- One block = one command

- Blocks go from left to right

1st Block   2nd Block   3rd Block

Programming the robots

Click on the green circle to show the different command blocks
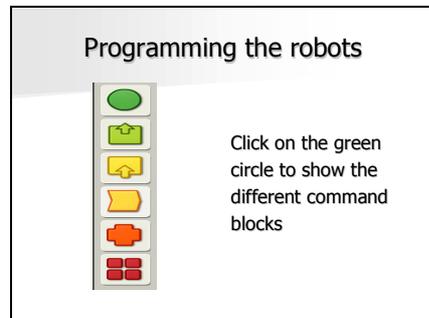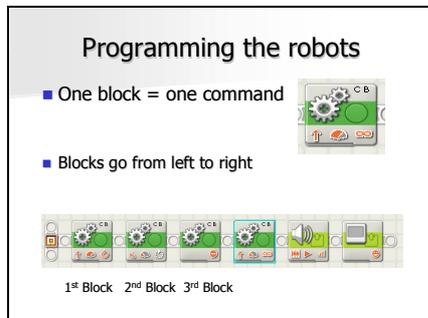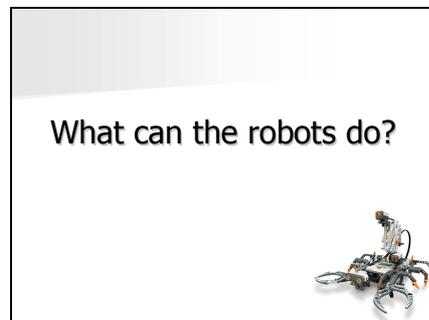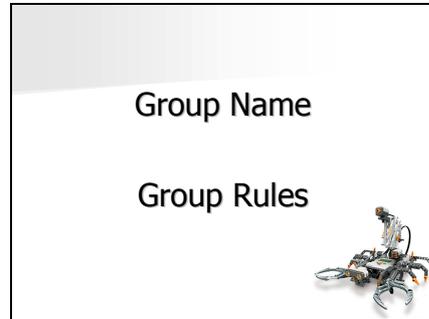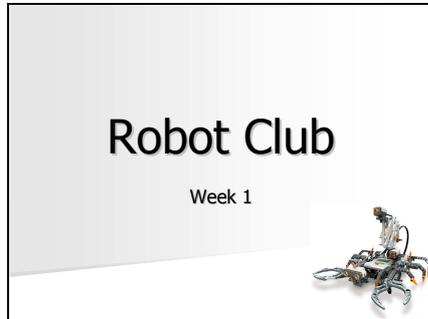
The Movement Command Block

Direction

Click one circle to pick the direction the robot will move:

Forward, Backward or Stop

Programming the robot to move

Task: To get the robot to move forwards or backwards and to stop

- Open MINDSTORMS NXT programme
- Drag and drop each command block onto the white bar
- When finished, connect robot to computer using cable
- Click on the 'download' button
- When the computer message says it has finished downloading, then unplug the robot
- On the panel on the actual robot, press the orange button to enter 'my files' → 'software files' → select the programme you just downloaded

Now we can see if it works!

The Movement Command Block

Steering (turning)

Drag the slider across to change how straight the robot will travel (watch the arrow in the middle to see how straight the robot will go!):

Turns the wheels to the left ←--------Go straight-------------→ Turns the wheels to the right

Programming the robot to move

- Task: To get the robot to move to the left or the right

- Drag and drop each command block onto the white bar
- When finished, connect robot to computer using cable
- Click on the 'download' button
- When the computer message says it has finished downloading, then unplug the robot
- On the panel on the actual robot, press the orange button to enter 'my files' → 'software files' → select the programme you just downloaded

The Movement Command Block

Power (speed)

Drag the slider across to change how fast the motors will spin:

Slowly ←--→ Quickly
(like a snail) (like a cheetah)

You should usually put the slider somewhere in the middle.

Programming the robot to move

- Task: To get the robot to move faster or slower

- Drop and drag the command blocks
- Can you remember how to download the programme to the robot?

Today's Task

Programme your robot to:
- Move forward
- Then to stop
- Then to turn left
- Then to move backwards
- And finally to stop again

Robot Club

Week 2

Group Rules

What do you remember?

What do you remember?

What do you remember?

Can you programme your robot to:

1. Move forward or backwards
2. Left or right
3. Fast or slow

Programming the robots

Click on the light orange shape to show the options to make your own command block

The Waiting Command Block

- This makes your robot pause what it's doing and wait

- It can wait for a certain amount of time or for the sensor to detect something

The Waiting Command Block

This drop down button controls what we are waiting for: a **sensor reading** or an **amount of time.**

If you selected **sensor reading** above, then you can select which sensor you'll be using and the sensor's console will appear on the right.

The Waiting Command Block

This drop down button controls what we are waiting for: a **sensor reading** or an **amount of time.**

If you selected **time**, you can type in how many seconds the robot should wait for.

Programming the robot to wait

Task: To get the robot to move forward for 4 seconds & then to wait for 4 seconds

Today's Task

Programme your robot to move around the arena using the movement and waiting blocks:

- Go forward for 4 seconds
- Wait for 2 seconds
- Then go backwards for 3 seconds
- Wait for 2 seconds
- Turn right and move for 2 seconds
- Wait for 3 seconds
- Turn left for 2 seconds
- Wait for 2 seconds

Robot Club

Week 3

What do you remember?

What do you remember?

What do you remember?

Can you programme your robot to:

- Move forwards or backwards or turn
- Wait for 3 seconds
- Then to move again

The Sonar Command Block

- How does sonar work?

- Ultrasonic sonar is used by our robots to sense objects in front of them. It's called ultrasonic because it uses sound waves (sonic) that are too high-pitched (ultra) for us to hear.

Programming the robots

The Sonar Command Block

Click one of these circles to select which sensor port the sonar sensor is plugged into.

You should usually click "4"
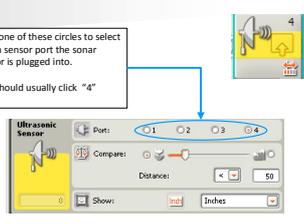
The Sonar Command Block
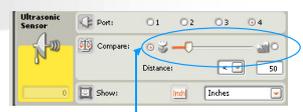
This lets you choose the **distance** that the robot needs to sense through a **sonar reading**. You can either type a number into the box or drag the slider to select the **target distance**:

Very close ←--→ Very far away
to the robot   from the robot

Then you can select from the dropdown box on the left how the robot will compare the **target distance** to the **sonar reading**:

< if **sonar reading** is *less than* **target distance**
> if **sonar reading** is *greater than* **target distance**

The Sonar Command Block

This drop down box lets you decide whether the distances are measured in inches (in) or centimetres (cm).

1 inch = 2.54 cm

Today's Task

Programme your robot to stop when is senses it is a set distance from the edge of the arena

- Choose and measure your distance
- Create computer sequence
- Download to robot
- Measure to check your robot was accurate!

Today's Task 2

Programme your robot to:
- Move alongside the walls of the arena and to turn right at each corner
- The robot must be 20cm from the edge of the arena before it turns
- Keep going until the robot gets back to where it started

Good luck

Robot Club

Week 4

What do you remember?

What do you remember?

Can you programme your robot to:

- Move alongside the walls of the arena and to turn right at each corner
- The robot must be 20cm from the edge of the arena before it turns
- Keep going until the robot gets back to where it started

Hint: Repeat this pattern four times (but end with a stop block on the last repeat)

Working together

How do you know when it is your turn?

What signs do you look for?

Robots working together

- Use their sensors to detect where each other are and to know what to do next

- Take turns

- Follow instructions

Today's Task

- How can we make the robot's work together using different instructions for each robot?

- Hint: Think about using the sonar with the move and wait blocks

What each robot should do

Orange Robot Group:

- Move forward forever until you sense another robot on sonar within 10 cm
- Then stop

<10 cm

What each robot should do

Yellow Robot Group:

- Wait until you sense another robot within 20 cm
- Turn to face the wall where the white group's robot is
- Move forward forever until you sense another robot on sonar within 10 cm
- Stop
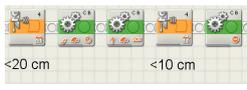
<20 cm   <10 cm

What each robot should do

White Robot Group:

- Wait until you sense another robot within 20 cm
- Turn around to face the opposite wall
- Move forward forever until you sense a wall on sonar within 10 cm
- Stop

<20 cm   <10 cm

Free programming time

- Programme your robot using any of the command blocks you have learnt so far
- Then we will watch what each group has come up with

- Can you work out what command blocks the other groups have used by watching their robots?

Good luck!
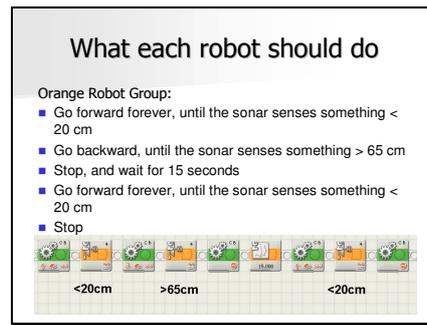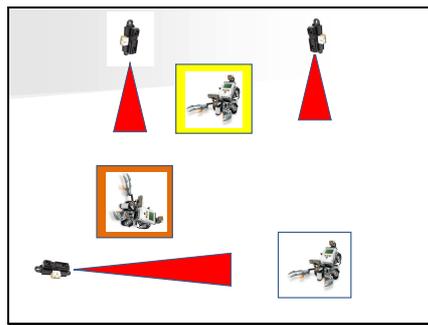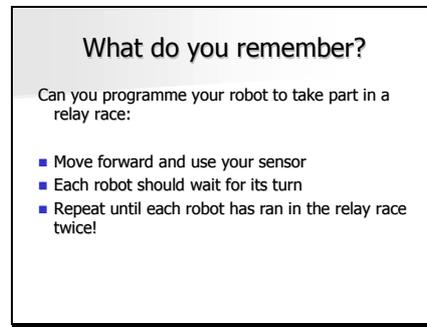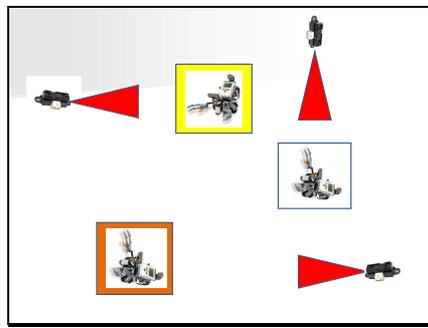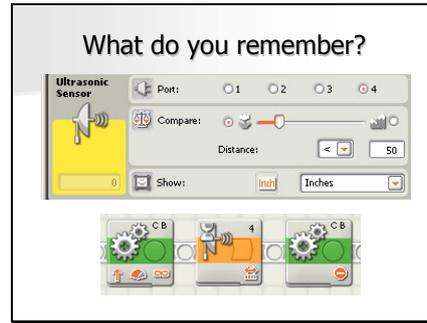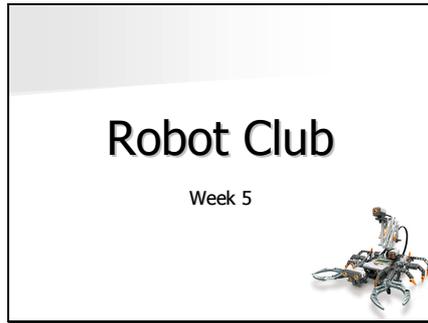
Robot Club

Week 5

What do you remember?

What do you remember?

Can you programme your robot to take part in a relay race:

- Move forward and use your sensor
- Each robot should wait for its turn
- Repeat until each robot has ran in the relay race twice!

What each robot should do

Orange Robot Group:
- Go forward forever, until the sonar senses something < 20 cm
- Go backward, until the sonar senses something > 65 cm
- Stop, and wait for 15 seconds
- Go forward forever, until the sonar senses something < 20 cm
- Stop

What each robot should do

Yellow Robot Group:
- Wait until the sonar senses something < 20 cm
- Rotate once to the left
- Go forward forever, until the sonar senses something < 20 cm
- Go backward forever, until the sonar senses something > 150 cm
- Rotate once to the right
- Wait until the sonar senses something < 20 cm
- Rotate once to the left
- Go forward forever

<20cm   <20cm   >150cm   <20cm
1 rotation   1 rotation   1 rotation

What each robot should do

White Robot Group:
- Wait until the sonar senses something < 20 cm
- Rotate once to the right
- Go forward forever, until the sonar senses something < 20 cm
- Go backward forever, until the sonar senses something > 150 cm
- Rotate once to the left
- Wait until the sonar senses something < 20 cm
- Rotate once to the right
- Go forward forever

<20cm   <20cm   >150cm   <20cm
1 rotation   1 rotation   1 rotation

Programming the robots

Click on the light orange shape to find the loop command block

The Loop Command Block

- This makes the robot do the same movement over and over again until a special command is met.

The Loop Command Block

Types of commands or **control conditions**:

- Forever – the loop won't stop running
- Sensor – loops until it picks up a sensor reading
- Time – loops for a set amount of time (seconds)
- Count – runs the loop a set number of times (once, twice etc...)

The Loop Command Block

How to stop the loop:

- Sensor – selects which sensor to use
- Time – number of seconds the loop should run for
- Count – number of times the loop should repeat

The Loop Command Block

3a. If your **control condition** is not met, the robot goes back to the beginning of the loop (step 1)

3b. If your **control condition** is met, the robot breaks out of the loop

4. The robot then carries out the command that comes after the loop!

1. The robot carries out all the commands inside the loop

2. The robot tries to break out of the loop by seeing if it meets the **control condition** that you've set for it

Programming the robot to loop

Programme your robot to:

- Wait until sonar reading is < 20cm away from the wall
- When it gets to this distance, rotates 180 degrees
- Do this 4 times!

<20 cm 180 deg

Count =4

Today's Task

- Make your robots pace back and forth, using their sonar to trigger the robots to change direction

- We will start each robot at different positions in the arena

- Using paper to trigger your robot's sonar, we will make all the robots get close to the arena's sensors at the same time!

Today's Task

Inside of a loop going forever programme your robots to:

- Go forward forever until the sonar reads < 20 cm
- Go backward until your sonar reads > 150 cm

<20cm   >150cm

Robot Club

Week 6

What do you remember?
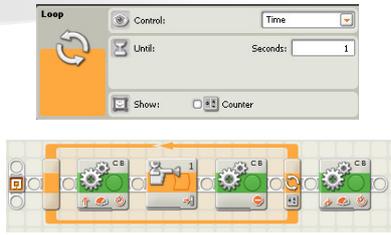
What do you remember?

Can you programme your robot using the loop command block to:

- Wait for a specific sonar reading (20 cm away from the wall) before spinning

<20cm 2 rotate

Count = 4
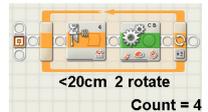
The Light Sensor

- This tells the robot how much light it sees
- It can look straight as the light (e.g. the sun or a lamp) or an object that reflects light
- This works with objects of any colour

- On our robots the light sensor is on the bottom
- They can use this sensor to figure out when something on the floor has changed colour

---

Programming the robots
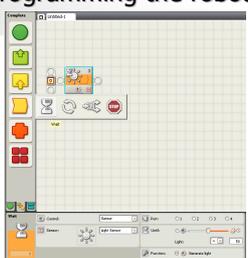
The Light Sensor Command Block

This makes the sensor block check whether the sensor reading is more or less than the specified amount of light.
> --- More than
< --- Less than

You can more the slider to change the amount, or type in the number

The Light Sensor Command Block
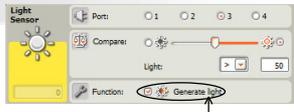
Tick this box when you are not shinning a light on the robots light sensor

This makes the sensor shine a light on the different objects / colours when it takes a reading

Today's Task

Programme your robots to move and wait using the light sensor:

- Make your robot move forward until it drives over a bright patch on the floor
- For the "Wait" block, choose the light sensor instead of the ultrasonic one
- We will use white paper to make the robot think there is a bright patch on the floor

>50

The Compass Sensor

- What the robot sees
- What a person would read

- This tells the robot the direction that it's facing
- The compass sensor uses numbers instead of letters
- This means that the robots will always know their heading, or the direction they're facing

Making Your Own Command Block

- We've made a special block that uses the compass sensor to make your robot turn 90 degrees clockwise automatically!

- You can use this special block by clicking on the two blue lines at the bottom
- The select the top block with a symbol of a person on it
- Click and drag the block with the exclamation mark on

Today's Task

Programme your robots to rotate by 90 degrees when something comes close to its compass sonar:

RotateBy90

<30cm
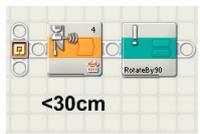
Final Task!

Wall of lights:
- Program your robots to always
  – Go straight ahead forever
  – Rotate 90 degrees if they drive over a white piece of paper on the ground
- Once the robots are doing this correctly, we'll play a game with all of the robots in the arena trying to activate all the sensors!

>50

Robot Club

Week 7

What do you remember?

- How did we use paper to trick the robots light sensor?

What do you remember?

<30cm
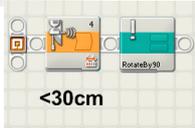
- What does the robot use its compass sensor for?

What do you remember?

Wall of lights:
- Can you program your robots to always
  - Go straight ahead forever
  - Rotate 90 degrees if they drive over a white piece of paper on the ground

>50
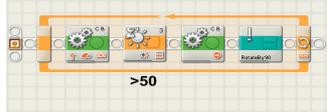
The Touch Sensor

- This is a button on the robot
- The robot can sense whether the button is being pressed or not, or whether it is being held down

- We will use this sensor to tell the robot when it has caught an object that it should hold on to

Programming the robots

The Touch Sensor Command Block

Click one of these circles to select which sensor port the touch sensor is plugged into.

Ours are on port 1.

Port: ○1 ○2 ○3 ○4

Action: ○ Pressed ○ Released ○ Bumped

By selecting one of these options, you'll choose which action will trigger the sensor:
1. Pressing in the touch sensor (and holding it down)
2. Not pressing it in
3. Bumping into it (press once and let go)

Controlling the Grippers

- The grippers can be used to grab hold of an object

- We will use a motor command block to control the grippers

The Motor Command Block

Click on A for the gripper's motor

Port: ○ A ○ B ○ C

Direction:

Forward = open grippers
Back = close grippers

Always set duration to 90 degrees!

Today's Task

Programme your robot to:
- Open the robot's grippers
- Go forward forever
- Wait until the touch sensor is pressed
- Close the grippers and stop moving

→ Make sure the robots grippers are closed before running this program!

90 deg   90 deg

Final task

Programme your robot to go through the assault course:
- Wading though the "water"
- Turn 90'
- Go forward and stop at white "stairs"
- Rotate by 90' 5 times to "go up" the stairs.
- Open grippers and go forward until the touch sensor is pushed
- Close grippers and go forward

>50   Count=5   90deg   90deg

230

Robot Club

Week 8

What do you remember?

- The movement (forward, backwards, turn and stop) and waiting blocks
- Waiting for time or using the ultra sonic sensor to wait for a specific distance
- Using these blocks to get the robots to work together

What do you remember?

- Using the loop to get the robots to do something over and over again

- Using the robots different sensors: Light, compass and touch

- Moving the grippers with the motor command block
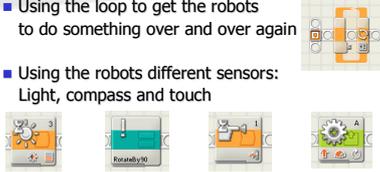
What do you remember?

Wall of lights:
- Can you program your robots to always
  – Go straight ahead forever
  – Rotate 90 degrees if they drive over a white piece of paper on the ground

>50
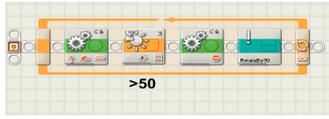
Using everything we have learnt

- Using one series of blocks you can get the robots to do different things!

- You get to choose how much you want the robots to work together!

- The arena will react differently depending on how cooperatively the robots are playing!

How the arena will react

- Plays shorter, simpler sounds
- Flashes lights slowly

- Plays longer music
- Flashes lights quickly

One robot working alone

One robot after pushing coloured beads to radio sensor

Two robots working together

Two robots working together after pushing coloured beads to radio sensor
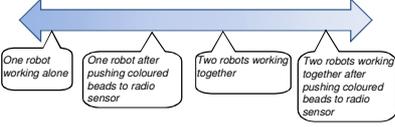
How the robots triggers the arena sensors

Today's Task

Can you program the robots to:
- Open their grippers
- Go forward forever until something pushes in their touch sensor, then close the grippers
- Inside of a loop going forever:
  – Go forward forever until they drive over a bright (>50) piece of paper
  – Rotate 90'

90 deg   **90 deg**   **>50**

Free programming time

Using the today's task programme:
- In your pairs, show your parents how you can get your robots to interact with each other and the arena

- You will then have time to design your own programmes to test out with your parents

Appendix D: Outcome measures

1. GARS-2 (title page only, not for copying, were purchased and are copyrighted)
2. SSIS (title page only, not for copying, were purchased and are copyrighted)
3. SDQ (freely available online for downloading and copying)
4. Parent rated behaviour checklist (not for copying without permission from the authors)
5. CGAS (freely available online for downloading and copying)
6. Goal Based Outcomes (designed specifically for this study; not for copying without permission from the author)
7. Evaluation forms (designed specifically for this study; not for copying without permission from the author)

GARS-2
Gilliam Autism Rating Scale–Second Edition
Summary/Response Booklet

Section I. Identifying Information

Individual's Name _____   Male ☐   Female ☐   Grade _____

	Year	Month	Day
Date of Rating	___	___	___
Date of Birth	___	___	___
Age	___	___	___

School _____
Rater's Name _____
Examiner's Name _____
Examiner's Title _____

Section II. Score Summary

Subscales	Raw Score	Standard Score	%ile	SEM
Stereotyped Behaviors	___	___ . ___	___	1
Communication	___	___	___	1
Social Interaction	___	___	___	1
Sum of Standard Scores	___			
Autism Index	☐	☐		4

Section III. Interpretation Guide

Subscale Standard Score	Autism Index	Probability of Autism
7 or Higher	85 or Higher	Very Likely
4 to 6	70 to 84	Possibly
1 to 3	69 or Less	Unlikely

Section IV. Profile of Scores

Standard Score	Stereotyped Behaviors	Communication	Social Interaction	Autism Index
20	•	•	•	150
19	•	•	•	145
18	•	•	•	140
17	•	•	•	135
16	•	•	•	130
15	•	•	•	125
14	•	•	•	120
13	•	•	•	115
12	•	•	•	110
11	•	•	•	105
10	•	•	•	100
9	•	•	•	95
8	•	•	•	90
7	•	•	•	85
6	•	•	•	80
5	•	•	•	75
4	•	•	•	70
3	•	•	•	65
2	•	•	•	60
1	•	•	•	55

SSiS Social Skills Improvement System

Rating Scales
Parent
Hand-Scoring Form

Frank M. Gresham, PhD, and Stephen N. Elliott, PhD

Instructions

This booklet contains statements describing your child's behavior and consists of two parts: Social Skills and Problem Behaviors.

Social Skills & Problem Behaviors

Please read each item and think about your child's behavior during the past two months. Then, decide **how often** your child displays the behavior.

If your child **never** behaves this way, circle the **N**.
If your child **seldom** behaves this way, circle the **S**.
If your child **often** behaves this way, circle the **O**.
If your child **almost always** behaves this way, circle the **A**.

For each of the Social Skills items, please also rate **how important** you think the behavior is for your child's development.

If you think the behavior is **not important** for your child's development, circle the **n**.
If you think the behavior is **important** for your child's development, circle the **i**.
If you think the behavior is **critical** for your child's development, circle the **c**.

How to Mark Your Responses

When marking responses, use a sharp pencil or ballpoint pen; do not use a felt-tip pen or marker. Press firmly, and be certain to **circle** completely the letter you choose, like this:

N S (O) A
(n) i c
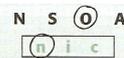
If you wish to change a response, mark an **X** through it, and **circle** your new choice, like this:

N (S) O (X)
n i (c)
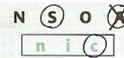
Please mark every item. If you are uncertain of your response to an item, give your best estimate. There are no right or wrong answers.

Before starting, be sure to complete the information in the boxes on the right-hand side of page 3.

PEARSON

1

Strengths and Difficulties Questionnaire   P 4-16

For each item, please mark the box for Not True, Somewhat True or Certainly True. It would help us if you answered all items as best you can even if you are not absolutely certain or the item seems daft! Please give your answers on the basis of the child's behaviour over the last six months.

Child's Name ....   Male/Female

Date of Birth...

	Not True	Somewhat True	Certainly True
Considerate of other people's feelings	☐	☐	☐
Restless, overactive, cannot stay still for long	☐	☐	☐
Often complains of headaches, stomach-aches or sickness	☐	☐	☐
Shares readily with other children (treats, toys, pencils etc.)	☐	☐	☐
Often has temper tantrums or hot tempers	☐	☐	☐
Rather solitary, tends to play alone	☐	☐	☐
Generally obedient, usually does what adults request	☐	☐	☐
Many worries, often seems worried	☐	☐	☐
Helpful if someone is hurt, upset or feeling ill	☐	☐	☐
Constantly fidgeting or squirming	☐	☐	☐
Has at least one good friend	☐	☐	☐
Often fights with other children or bullies them	☐	☐	☐
Often unhappy, down-hearted or tearful	☐	☐	☐
Generally liked by other children	☐	☐	☐
Easily distracted, concentration wanders	☐	☐	☐
Nervous or clingy in new situations, easily loses confidence	☐	☐	☐
Kind to younger children	☐	☐	☐
Often lies or cheats	☐	☐	☐
Picked on or bullied by other children	☐	☐	☐
Often volunteers to help others (parents, teachers, other children)	☐	☐	☐
Thinks things out before acting	☐	☐	☐
Steals from home, school or elsewhere	☐	☐	☐
Gets on better with adults than with other children	☐	☐	☐
Many fears, easily scared	☐	☐	☐
Sees tasks through to the end, good attention span	☐	☐	☐

Do you have any other comments or concerns?

Please turn over - there are a few more questions on the other side

Overall, do you think that your child has difficulties in one or more of the following areas: emotions, concentration, behaviour or being able to get on with other people?

	No	Yes- minor difficulties	Yes- definite difficulties	Yes- severe difficulties
	☐	☐	☐	☐

If you have answered "Yes", please answer the following questions about these difficulties:

● How long have these difficulties been present?

	Less than a month	1-5 months	6-12 months	Over a year
	☐	☐	☐	☐

● Do the difficulties upset or distress your child?

	Not at all	Only a little	Quite a lot	A great deal
	☐	☐	☐	☐

● Do the difficulties interfere with your child's everyday life in the following areas?

	Not at all	Only a little	Quite a lot	A great deal
HOME LIFE	☐	☐	☐	☐
FRIENDSHIPS	☐	☐	☐	☐
CLASSROOM LEARNING	☐	☐	☐	☐
LEISURE ACTIVITIES	☐	☐	☐	☐

● Do the difficulties put a burden on you or the family as a whole?

	Not at all	Only a little	Quite a lot	A great deal
	☐	☐	☐	☐

Signature .... Date ....

Mother/Father/Other (please specify:)

Thank you very much for your help

Strengths and Difficulties Questionnaire   P4-16

FOLLOW-UP

For each item, please mark the box for Not True, Somewhat True or Certainly True. It would help us if you answered all items as best you can even if you are not absolutely certain or the item seems daft! Please give your answers on the basis of your child's behaviour **over the last month**.

Child's Name ....   Male/Female

Date of Birth...

	Not True	Somewhat True	Certainly True
Considerate of other people's feelings	☐	☐	☐
Restless, overactive, cannot stay still for long	☐	☐	☐
Often complains of headaches, stomach-aches or sickness	☐	☐	☐
Shares readily with other children (treats, toys, pencils etc.)	☐	☐	☐
Often has temper tantrums or hot tempers	☐	☐	☐
Rather solitary, tends to play alone	☐	☐	☐
Generally obedient, usually does what adults request	☐	☐	☐
Many worries, often seems worried	☐	☐	☐
Helpful if someone is hurt, upset or feeling ill	☐	☐	☐
Constantly fidgeting or squirming	☐	☐	☐
Has at least one good friend	☐	☐	☐
Often fights with other children or bullies them	☐	☐	☐
Often unhappy, down-hearted or tearful	☐	☐	☐
Generally liked by other children	☐	☐	☐
Easily distracted, concentration wanders	☐	☐	☐
Nervous or clingy in new situations, easily loses confidence	☐	☐	☐
Kind to younger children	☐	☐	☐
Often lies or cheats	☐	☐	☐
Picked on or bullied by other children	☐	☐	☐
Often volunteers to help others (parents, teachers, other children)	☐	☐	☐
Thinks things out before acting	☐	☐	☐
Steals from home, school or elsewhere	☐	☐	☐
Gets on better with adults than with other children	☐	☐	☐
Many fears, easily scared	☐	☐	☐
Sees tasks through to the end, good attention span	☐	☐	☐

Do you have any other comments or concerns?

Please turn over - there are a few more questions on the other side

Since coming to the clinic, are your child's problems:

Much worse	A bit worse	About the same	A bit better	Much better
☐	☐	☐	☐	☐

Has coming to the clinic been helpful in other ways, e.g. providing information or making the problems more bearable?

Not at all	Only a little	Quite a lot	A great deal
☐	☐	☐	☐

Over the last month, has your child had difficulties in one or more of the following areas: emotions, concentration, behaviour or being able to get on with other people?

No	Yes-minor difficulties	Yes-definite difficulties	Yes-severe difficulties
☐	☐	☐	☐

If you have answered "Yes", please answer the following questions about these difficulties:

● Do the difficulties upset or distress your child?

Not at all	Only a little	Quite a lot	A great deal
☐	☐	☐	☐

● Do the difficulties interfere with your child's everyday life in the following areas?

	Not at all	Only a little	Quite a lot	A great deal
HOME LIFE	☐	☐	☐	☐
FRIENDSHIPS	☐	☐	☐	☐
CLASSROOM LEARNING	☐	☐	☐	☐
LEISURE ACTIVITIES	☐	☐	☐	☐

● Do the difficulties put a burden on you or the family as a whole?

Not at all	Only a little	Quite a lot	A great deal
☐	☐	☐	☐

Signature .... Date ....

Mother/Father/Other (please specify:)

Thank you very much for your help

Strengths and Difficulties Questionnaire   T$^{4\text{-}16}$

For each item, please mark the box for Not True, Somewhat True or Certainly True. It would help us if you answered all items as best you can even if you are not absolutely certain or the item seems daft! Please give your answers on the basis of the child's behaviour over the last six months or this school year.

Child's Name ....   Male/Female

Date of Birth..

	Not True	Somewhat True	Certainly True
Considerate of other people's feelings	☐	☐	☐
Restless, overactive, cannot stay still for long	☐	☐	☐
Often complains of headaches, stomach-aches or sickness	☐	☐	☐
Shares readily with other children (treats, toys, pencils etc.)	☐	☐	☐
Often has temper tantrums or hot tempers	☐	☐	☐
Rather solitary, tends to play alone	☐	☐	☐
Generally obedient, usually does what adults request	☐	☐	☐
Many worries, often seems worried	☐	☐	☐
Helpful if someone is hurt, upset or feeling ill	☐	☐	☐
Constantly fidgeting or squirming	☐	☐	☐
Has at least one good friend	☐	☐	☐
Often fights with other children or bullies them	☐	☐	☐
Often unhappy, down-hearted or tearful	☐	☐	☐
Generally liked by other children	☐	☐	☐
Easily distracted, concentration wanders	☐	☐	☐
Nervous or clingy in new situations, easily loses confidence	☐	☐	☐
Kind to younger children	☐	☐	☐
Often lies or cheats	☐	☐	☐
Picked on or bullied by other children	☐	☐	☐
Often volunteers to help others (parents, teachers, other children)	☐	☐	☐
Thinks things out before acting	☐	☐	☐
Steals from home, school or elsewhere	☐	☐	☐
Gets on better with adults than with other children	☐	☐	☐
Many fears, easily scared	☐	☐	☐
Sees tasks through to the end, good attention span	☐	☐	☐

Do you have any other comments or concerns?

Please turn over - there are a few more questions on the other side

Overall, do you think that this child has difficulties in one or more of the following areas:
emotions, concentration, behaviour or being able to get on with other people?

	No	Yes- minor difficulties	Yes- definite difficulties	Yes- severe difficulties
	☐	☐	☐	☐

If you have answered "Yes", please answer the following questions about these difficulties:

● How long have these difficulties been present?

	Less than a month	1-5 months	6-12 months	Over a year
	☐	☐	☐	☐

● Do the difficulties upset or distress the child?

	Not at all	Only a little	Quite a lot	A great deal
	☐	☐	☐	☐

● Do the difficulties interfere with the child's everyday life in the following areas?

	Not at all	Only a little	Quite a lot	A great deal
PEER RELATIONSHIPS	☐	☐	☐	☐
CLASSROOM LEARNING	☐	☐	☐	☐

● Do the difficulties put a burden on you or the class as a whole?

	Not at all	Only a little	Quite a lot	A great deal
	☐	☐	☐	☐

Signature .... Date ....

Class Teacher/Form Tutor/Head of Year/Other (please specify:)

Thank you very much for your help

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Strengths and Difficulties Questionnaire

T4-16

FOLLOW-UP

For each item, please mark the box for Not True, Somewhat True or Certainly True. It would help us if you answered all items as best you can even if you are not absolutely certain or the item seems daft! Please give your answers on the basis of the child's behaviour **over the last month**.

Child's Name ....   Male/Female

Date of Birth..

	Not True	Somewhat True	Certainly True
Considerate of other people's feelings	☐	☐	☐
Restless, overactive, cannot stay still for long	☐	☐	☐
Often complains of headaches, stomach-aches or sickness	☐	☐	☐
Shares readily with other children (treats, toys, pencils etc.)	☐	☐	☐
Often has temper tantrums or hot tempers	☐	☐	☐
Rather solitary, tends to play alone	☐	☐	☐
Generally obedient, usually does what adults request	☐	☐	☐
Many worries, often seems worried	☐	☐	☐
Helpful if someone is hurt, upset or feeling ill	☐	☐	☐
Constantly fidgeting or squirming	☐	☐	☐
Has at least one good friend	☐	☐	☐
Often fights with other children or bullies them	☐	☐	☐
Often unhappy, down-hearted or tearful	☐	☐	☐
Generally liked by other children	☐	☐	☐
Easily distracted, concentration wanders	☐	☐	☐
Nervous or clingy in new situations, easily loses confidence	☐	☐	☐
Kind to younger children	☐	☐	☐
Often lies or cheats	☐	☐	☐
Picked on or bullied by other children	☐	☐	☐
Often volunteers to help others (parents, teachers, other children)	☐	☐	☐
Thinks things out before acting	☐	☐	☐
Steals from home, school or elsewhere	☐	☐	☐
Gets on better with adults than with other children	☐	☐	☐
Many fears, easily scared	☐	☐	☐
Sees tasks through to the end, good attention span	☐	☐	☐

Do you have any other comments or concerns?

Please turn over - there are a few more questions on the other side

Since coming to the clinic, are the child's problems:

Much worse	A bit worse	About the same	A bit better	Much better
☐	☐	☐	☐	☐

Has coming to the clinic been helpful in other ways, e.g. providing information or making the problems more bearable?

Not at all	Only a little	Quite a lot	A great deal
☐	☐	☐	☐

Over the last month, has the child had difficulties in one or more of the following areas: emotions, concentration, behaviour or being able to get on with other people?

No	Yes- minor difficulties	Yes- definite difficulties	Yes- severe difficulties
☐	☐	☐	☐

If you have answered "Yes", please answer the following questions about these difficulties:

● Do the difficulties upset or distress the child?

Not at all	Only a little	Quite a lot	A great deal
☐	☐	☐	☐

● Do the difficulties interfere with the child's everyday life in the following areas?

	Not at all	Only a little	Quite a lot	A great deal
PEER RELATIONSHIPS	☐	☐	☐	☐
CLASSROOM LEARNING	☐	☐	☐	☐

● Do the difficulties put a burden on you or the class as a whole?

Not at all	Only a little	Quite a lot	A great deal
☐	☐	☐	☐

Signature .... Date ....

Class Teacher/Form Tutor/Head of Year/Other (please specify):

Thank you very much for your help   © Robert Goodman, 2005

Strengths and Difficulties Questionnaire   S 11-16

For each item, please mark the box for Not True, Somewhat True or Certainly True. It would help us if you answered all items as best you can even if you are not absolutely certain or the item seems daft! Please give your answers on the basis of how things have been for you over the last six months.

Your Name ....   Male/Female

Date of Birth..

	Not True	Somewhat True	Certainly True
I try to be nice to other people. I care about their feelings	☐	☐	☐
I am restless, I cannot stay still for long	☐	☐	☐
I get a lot of headaches, stomach-aches or sickness	☐	☐	☐
I usually share with others (food, games, pens etc.)	☐	☐	☐
I get very angry and often lose my temper	☐	☐	☐
I am usually on my own. I generally play alone or keep to myself	☐	☐	☐
I usually do as I am told	☐	☐	☐
I worry a lot	☐	☐	☐
I am helpful if someone is hurt, upset or feeling ill	☐	☐	☐
I am constantly fidgeting or squirming	☐	☐	☐
I have one good friend or more	☐	☐	☐
I fight a lot. I can make other people do what I want	☐	☐	☐
I am often unhappy, down-hearted or tearful	☐	☐	☐
Other people my age generally like me	☐	☐	☐
I am easily distracted, I find it difficult to concentrate	☐	☐	☐
I am nervous in new situations. I easily lose confidence	☐	☐	☐
I am kind to younger children	☐	☐	☐
I am often accused of lying or cheating	☐	☐	☐
Other children or young people pick on me or bully me	☐	☐	☐
I often volunteer to help others (parents, teachers, children)	☐	☐	☐
I think before I do things	☐	☐	☐
I take things that are not mine from home, school or elsewhere	☐	☐	☐
I get on better with adults than with people my own age	☐	☐	☐
I have many fears, I am easily scared	☐	☐	☐
I finish the work I'm doing. My attention is good	☐	☐	☐

Do you have any other comments or concerns?

Please turn over - there are a few more questions on the other side

Overall, do you think that you have difficulties in one or more of the following areas:
emotions, concentration, behaviour or being able to get on with other people?

	No	Yes- minor difficulties	Yes- definite difficulties	Yes- severe difficulties
	☐	☐	☐	☐

If you have answered "Yes", please answer the following questions about these difficulties:

● How long have these difficulties been present?

	Less than a month	1-5 months	6-12 months	Over a year
	☐	☐	☐	☐

● Do the difficulties upset or distress you?

	Not at all	Only a little	Quite a lot	A great deal
	☐	☐	☐	☐

● Do the difficulties interfere with your everyday life in the following areas?

	Not at all	Only a little	Quite a lot	A great deal
HOME LIFE	☐	☐	☐	☐
FRIENDSHIPS	☐	☐	☐	☐
CLASSROOM LEARNING	☐	☐	☐	☐
LEISURE ACTIVITIES	☐	☐	☐	☐

● Do the difficulties make it harder for those around you (family, friends, teachers, etc.)?

	Not at all	Only a little	Quite a lot	A great deal
	☐	☐	☐	☐

Your Signature ....

Today's Date ....

Thank you very much for your help

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Strengths and Difficulties Questionnaire

S11-16
FOLLOW-UP

For each item, please mark the box for Not True, Somewhat True or Certainly True. It would help us if you answered all items as best you can even if you are not absolutely certain or the item seems daft! Please give your answers on the basis of how things have been for you **over the last month**.

Your Name .... Male/Female

Date of Birth...

	Not True	Somewhat True	Certainly True
I try to be nice to other people. I care about their feelings	☐	☐	☐
I am restless, I cannot stay still for long	☐	☐	☐
I get a lot of headaches, stomach-aches or sickness	☐	☐	☐
I usually share with others (food, games, pens etc.)	☐	☐	☐
I get very angry and often lose my temper	☐	☐	☐
I am usually on my own. I generally play alone or keep to myself	☐	☐	☐
I usually do as I am told	☐	☐	☐
I worry a lot	☐	☐	☐
I am helpful if someone is hurt, upset or feeling ill	☐	☐	☐
I am constantly fidgeting or squirming	☐	☐	☐
I have one good friend or more	☐	☐	☐
I fight a lot. I can make other people do what I want	☐	☐	☐
I am often unhappy, down-hearted or tearful	☐	☐	☐
Other people my age generally like me	☐	☐	☐
I am easily distracted, I find it difficult to concentrate	☐	☐	☐
I am nervous in new situations. I easily lose confidence	☐	☐	☐
I am kind to younger children	☐	☐	☐
I am often accused of lying or cheating	☐	☐	☐
Other children or young people pick on me or bully me	☐	☐	☐
I often volunteer to help others (parents, teachers, children)	☐	☐	☐
I think before I do things	☐	☐	☐
I take things that are not mine from home, school or elsewhere	☐	☐	☐
I get on better with adults than with people my own age	☐	☐	☐
I have many fears, I am easily scared	☐	☐	☐
I finish the work I'm doing. My attention is good	☐	☐	☐

Do you have any other comments or concerns?

Please turn over - there are a few more questions on the other side

Since coming to the clinic, are your problems:

Much worse	A bit worse	About the same	A bit better	Much better
☐	☐	☐	☐	☐

Has coming to the clinic been helpful in other ways, e.g. providing information or making the problems more bearable?

Not at all	Only a little	Quite a lot	A great deal
☐	☐	☐	☐

Over the last month, have you had difficulties in one or more of the following areas: emotions, concentration, behaviour or being able to get on with other people?

No	Yes- minor difficulties	Yes- definite difficulties	Yes- severe difficulties
☐	☐	☐	☐

If you have answered "Yes", please answer the following questions about these difficulties:

● Do the difficulties upset or distress you?

Not at all	Only a little	Quite a lot	A great deal
☐	☐	☐	☐

● Do the difficulties interfere with your everyday life in the following areas?

	Not at all	Only a little	Quite a lot	A great deal
HOME LIFE	☐	☐	☐	☐
FRIENDSHIPS	☐	☐	☐	☐
CLASSROOM LEARNING	☐	☐	☐	☐
LEISURE ACTIVITIES	☐	☐	☐	☐

● Do your difficulties make it harder for those around you (family, friends, teachers etc.)?

Not at all	Only a little	Quite a lot	A great deal
☐	☐	☐	☐

Your signature ....

Today's date ....

Thank you very much for your help

Parent rated behaviour checklist

Please use the following scale to assess how often your child does each of the following behaviours. It would be helpful to think about your child's behaviour over the last 2 weeks. For some items you may need to talk to other people who are important in your child's life e.g. grandparents, teachers and caregivers. To make the scale easier I have included how many times out of ten your child would do the behaviour.

1 = Never/rarely (0-1)
2= occasionally (1-4)
3= often (4-7)
4= frequently (7-9)
5= Always/usually (9-10)

Greeted Family appropriately	
Interrupted a conversation	
Started a conversation at an inappropriate time	
Was too friendly with strangers.	
Ignored someone who was trying to talking to them	
Continued talking despite non verbal cues to stop	
Initiated contact with a peer	
Ignored an instruction	
Greeted strangers appropriately	
Took their turn appropriately in a social setting	
Responded to a question by talking about something unrelated to the original statement	
Dominated a conversation	
Was able to incorporate someone else's idea into their play or conversation	
Realised what they were saying was inappropriate and changed what they were doing.	
Avoided touch e.g. a hug	
Showed signs of been overwhelmed	
Became angry or frustrated with no obvious trigger	
Compromised with a peer or sibling in a conflict situation	
Gave or received a compliment appropriately	
Was overly enthusiastic during a conversation	

Childrens Global Assessment Scale (CGAS)

1. Enter a score from 1-100
2. Rate the child/adolescents most impaired level of general functioning during the period rated by selecting the lowest level which describes his/her functioning on a hypothetical continuum of health-illness
3. Use intermediary levels eg. 35, 94, 68
4. Rate actual functioning regardless of treatment or prognosis, using the descriptions below as a guide

100-91	Superior functioning
90-81	Good functioning
80-71	No more than a slight impairment in functioning
70-61	Some difficulty in a single area, but generally functioning pretty well
60-51	Variable functioning with sporadic difficulties
50-41	Moderate degree of interference in functioning
40-31	Major impairment to functioning in several areas
30-21	Unable to function in almost all areas
20-11	Needs considerable supervision
10-1	Needs constant supervision

Principle reference

Schaffer D, Gould MS, Brasic J, et al. (1983) A children's global assessment scale (CGAS). *Archives of General Psychiatry,* 40, 1228-1231.

Description

The Childrens Global Assessment Scale (CGAS) is a measure developed by Schaffer and colleagues at the Department of Psychiatry, Columbia University to provide a global measure of level of functioning in children and adolescents. The measure provides a single global rating only, on scale of 0-100. In making their rating, the clinician makes use of the glossary details to determine the meaning of the points on the scale.

CGAS Glossary

Rate the patient's most impaired level of general functioning for the specified time period by selecting the *lowest* level which describes his/her functioning on a hypothetical continuum of health-illness. Use intermediary levels (eg 35, 58, 62).

Rate actual functioning regardless of treatment or prognosis. The examples of behaviour provided are only illustrative and are not required for a particular rating.

100-91 *Superior functioning* in all areas (at home, at school and with peers); involved in a wide range of activities and has many interests (eg., has hobbies or participates in extracurricular activities or belongs to an organised group such as Scouts, etc); likeable, confident; 'everyday' worries never get out of hand; doing well in school; no symptoms.

90-81 *Good functioning in all areas*; secure in family, school, and with peers; there may be transient difficulties and 'everyday' worries that occasionally get out of hand (eg., mild anxiety associated with an important exam, occasional 'blowups' with siblings, parents or peers).

80-71 *No more than slight impairments in functioning* at home, at school, or with peers; some disturbance of behaviour or emotional distress may be present in response to life stresses (eg., parental separations, deaths, birth of a sib), but these are brief and interference with functioning is transient; such children are only minimally disturbing to others and are not considered deviant by those who know them.

70-61 *Some difficulty in a single area but generally functioning pretty well* (eg., sporadic or isolated antisocial acts, such as occasionally playing hooky or petty theft; consistent minor difficulties with school work; mood changes of brief duration; fears and anxieties which do not lead to gross avoidance behaviour; self-doubts); has some meaningful interpersonal relationships; most people who do not know the child well would not consider him/her deviant but those who do know him/her well might express concern.

60-51 *Variable functioning with sporadic difficulties or symptoms in several but not all social areas;* disturbance would be apparent to those who encounter the child in a dysfunctional setting or time but not to those who see the child in other settings.

50-41 *Moderate degree of interference in functioning in most social areas or severe impairment of functioning in one area*, such as might result from, for example, suicidal preoccupations and ruminations, school refusal and other forms of anxiety, obsessive rituals, major conversion symptoms, frequent anxiety attacks, poor to inappropriate social skills, frequent episodes of aggressive or other antisocial behaviour with some preservation of meaningful social relationships.

40-31 *Major impairment of functioning in several areas and unable to function in one of these areas* (ie., disturbed at home, at school, with peers, or in society at large, eg., persistent aggression without clear instigation; markedly withdrawn and isolated behaviour due to either mood or thought disturbance, suicidal attempts with clear lethal intent; such children are likely to require special schooling and/or hospitalisation or withdrawal from school (but this is not a sufficient criterion for inclusion in this category).

30-21 *Unable to function in almost all areas* eg., stays at home, in ward, or in bed all day without taking part in social activities *or* severe impairment in reality testing *or* serious impairment in communication (eg., sometimes incoherent or inappropriate).

20-11 *Needs considerable supervision* to prevent hurting others or self (eg., frequently violent, repeated suicide attempts) *or* to maintain personal hygiene *or* gross impairment in all forms of communication, eg., severe abnormalities in verbal and gestural communication, marked social aloofness, stupor, etc.

10-1 *Needs constant supervision* (24-hour care) due to severely aggressive or self-destructive behaviour or gross impairment in reality testing, communication, cognition, affect or personal hygiene.

PERSONAL DIFFICULTIES AND GOALS

Child's Name:

Today's date:

These are the goals you set yourself before the 'Robot Club' started. They are the things that you find difficult when you are in a group with other children.

 Instructions: Please complete at the end of each 'Robot Club' meeting. Rate each of the following goals (by circling a number) according to how close you are to reaching that goal.

On a scale from zero to ten, please circle the number below that best describes how close you are to reaching each of your goals today. Remember: zero is as far away from your goal as you have ever been, ten is having reached your goal completely, and five is half way to reaching your goal.

List of goals

1.	1	2	3	4	5	6	7	8	9	10
2.	1	2	3	4	5	6	7	8	9	10
3.	1	2	3	4	5	6	7	8	9	10
4.	1	2	3	4	5	6	7	8	9	10
5.	1	2	3	4	5	6	7	8	9	10
6.	1	2	3	4	5	6	7	8	9	10
7.	1	2	3	4	5	6	7	8	9	10
8.	1	2	3	4	5	6	7	8	9	10
9.	1	2	3	4	5	6	7	8	9	10

ROBOT CLUB EVALUATION FORM

Please write as much or as little as you want for each question (go on to the other side of the page if you need to):

What did you like best about coming to the robot club?

What did you like the least about coming to the robot club?

	YES	NO
If you knew someone else with similar difficulties to you, would you recommend the robot club to them?		

What advice would you give to us if we were to run another robot club?

How have you found working with other people in the club? And what have you learnt about being in groups since coming to the club?

ROBOT CLUB EVALUATION FORM

Please write as much or as little as you want for each question (use the other side of the page if you need to):

What did you like best about the robot club and/or thought worked well?

What did you like the least about the robot club and/or thought did not work well?

	YES	NO
If you knew someone else with a child with similar difficulties, would you recommend the robot club to them? And why?		

What advice would you give to us if we were to run another robot club?

How do you think your child has found working with other people in the club? And what do you think they have learnt about being in groups since coming to the club?

Please add any other information that you feel is relevant to evaluating the robot club

Appendix E: Ethics application and approval certificate

	SCHOOL OF PSYCHOLOGY ETHICS APPLICATION FORM

Status: Doctorate in Clinical Psychology

Course code (if student): 06129561

Title of project: The Robot Club: Using robots as agents to improve social skills for young people on the autistic spectrum

Name of researcher(s): Sarah Blank

Contact Tel. no: 07879 638 636
Contact Email: S.T.Blank@herts.ac.uk

Name of supervisor: Primary Supervisor - Dr Nick Wood
                      Secondary Supervisor - Dr Ben Robins

Start Date of Study: November 2008

End Date of Study: September 2009 (viva date)

Number of participants: 12 – 14 participants

		YES	NO	N/A
Q1	Will you describe the main experimental procedures to participants in advance, so that they are informed about what to expect?	✓		
Q2	Will you tell participants that their participation is voluntary?	✓		
Q3	Will you obtain written consent for participation?	✓		
Q4	If the research is observational, will you ask participants for their consent to being observed?	✓		
Q5	Will you tell participants that they may withdraw from the research at any time and for any reason?	✓		
Q6	Will you tell participants that their data will be treated with full confidentiality and that, if published it will not be identifiable as theirs?	✓		
Q7	Will you debrief participants at the end of their participation (i.e., give them a brief explanation of the study)?			✓

IMPORTANT NOTE: If you have indicated **NO** to any question from **1-7 above**, but do not think this raises ethical concerns (i.e., you have **ticked box A** on page 3), please give a full explanation in **Q19** on page 2.

		YES	NO	N/A
Q8	Will your project involve deliberately misleading participants in any way?		✓	
Q9	Will your project involve invasive procedures (e.g. blood sample, by mouth, catheter, injection)?		✓	
Q10	Will the study involve the administration of any substance(s)?		✓	
Q11	Will the study involve the administration of a mood questionnaire (e.g. BDI) containing a question(s) about suicide or significant mental health problems? (If yes, please refer to Psychology Ethics Guidelines for a standard protocol)		✓	
Q12	Is there any realistic risk of any participants experiencing either physical or psychological distress or discomfort?		✓	

Q13	Does your project involve work with animals?			✓	
Q14	Do participants fall into any of the following special groups? If they do, please refer to BPS guidelines. **Note that you may also need to obtain satisfactory CRB clearance (or equivalent for overseas students)**	Schoolchildren (under 18 years of age)	✓		
		People with learning or communication difficulties	✓		
		Patients		✓	
		People in custody		✓	
		People engaged in illegal activities (e.g. drug-taking)		✓	

IMPORTANT NOTE: If you have indicated **YES** to any question from **8 - 14** above, you should normally **tick Box B** below. If you ticked **YES** but think that your study does not raise ethical concerns, please, provide a full explanation in **Q19 in** the section below.

There is an obligation on the lead researcher to bring to the attention of the Psychology Ethics Committee any issues with ethical implications not clearly covered by the above checklist

Please answer **Q15-19** below. Provide appropriate information with sufficient detail. This will enable the reviewers to assess the ethical soundness of the study without asking you additional questions and will speed up the review process (**PLEASE, PROVIDE AT THE END OF THIS FORM AN EXAMPLE OF THE INFORMATION AND CONSENT FORMS, QUESTIONNAIRE(S), IF USING, AND ANY OTHER RELEVANT FORMS, E.G., DEBRIEF SHEET, ETC.)**

Q15	**Purpose of project and its academic rationale (preferably between 100 - 500 words):**
	This study is interested in whether human-robot interaction can improve the social skills of older children/young adolescents on the autistic spectrum, in particular within a group setting. With a specific interest in high functioning autism and/or Asperger's syndrome (AS) as these young people can engage in a higher level of social relationships and more complex emotions compared with low-functioning individuals with an autistic spectrum disorder (ASD) (Bauminger, 2002).
	Research has identified difficulties in social initiation and in social-emotional understanding as the major problem of individuals with a high-functioning ASD or AS, rather than social insensitivity or social disinterest (Bacon *et al.*, 1998; Sigman & Ruskin, 1999), i.e., many are socially motivated but lack the necessary skills for appropriate performance. Individuals with ASDs display marked impairments in the use of multiple non-verbal behaviours, such as eye-to-eye gaze, facial expressions, body postures, and gestures to regulate social interaction (American Psychiatric Association, 1994). In addition, these individuals often fail to monitor the effects of their conversations or behaviours on other people (Barry *et al.*, 2003). For example, they frequently monopolise conversations or walk away while others are trying to interact with them (Baron-Cohen & Bolton, 1993); all of which suggest impairment in the development of reciprocal social interaction and communication skills. Most interventions aimed at people with a high-functioning ASD therefore tend to be behavioural and aimed at addressing the social interaction and communication difficulties.
	A variety of social interventions have been designed to try and improve the reciprocal social interaction and communication skills of these young people. The research highlights the use of scripts, social stories, peer mediated approaches, peer tutoring, social games, self-management, pivotal response training, video modelling, modelling and reinforcement and direct instruction (see DiSalvo & Oswald, 2002; Krantz, 2000; Matson *et al.*, 2007; McConnell, 2002; Parsons & Mitchell, 2002; Reynhout & Carter, 2006; Rogers, 2000; Solomon *et al.*, 2004; Terpstra *et al.*, 2002; Weiss & Harris, 2001 for reviews). However, the current evidence is inconclusive as to the effect of such interventions and tends to focus on pre-schoolers and those in early childhood.
	The hyper-systemising theory of ASD proposes that people with ASD have an unusually strong drive to systemise; this can explain their preference for systems that change in highly lawful or predictable ways, why they become disabled when faced with systems characterised by less lawful change and their need for sameness or resistance to change (Baron-Cohen, 2008). Research into computerised agents and robots has also focussed on developing technologies to aid these systemising creations to better navigate our social world. Due to the predictable and systematic nature of

	computers and robots, young people with an ASD are often drawn to this form of interaction over social human contact, as they find the situations easier to predict and therefore easier to read how their behaviour is impacting on the interaction. These theories and findings have lead to the desire to develop the use of computers and robots as possible mediating interventions for improving the social skills of young people with an ASD (see Dautenhahn, 1999). Current research in this area has focussed on one-to-one interactions (e.g., Robins *et al*, 2004; Werry & Dautenhahn, 1999) and pairs of children (see Werry *et al*, 2001), with the majority of children at the low functioning end of the autistic spectrum, some with very limited verbal skills.
Q16	**Brief description of methods and measurements:** This study will use a multiple case design to quantitatively evaluate whether 12-14 young people who attend 'the robot club' show an improvement in their social skills. The club will teach the young people to programme and work with the robots to achieve tasks. This will require team work from the young people in order to succeed. Specifically, the young people will learn how to program Lego Mindstorms NXT robots and how to make them interact / work together in the real world. Session plans written for a previous running of this club will be used again, with removal of the sessions which were found to be too difficult/were not enjoyed by the young people (see Wainer et al (2008) for original exploratory study design and slides). It is anticipated that the group will run for 8 weeks, although the existing sessions will allow for up to 12 sessions as necessary. The group will run one afternoon a week. To enable more young people to attend, two groups will be run back to back lasting 1 hour each, with 6-7 young people attending each group. This will allow the young people to work in pairs/three's to each robot. Outcome measures looking at social skills, self-esteem, behaviour, general functioning as well as individually tailored goals will be completed prior to attending the club. These outcome measures would be completed again upon completion of the group. A pre and post group analysis would be conducted e.g., t-test / wilcoxon. Parent, teacher and self-reports will be sought. At each group meeting the social skills measure and individually tailored goals would be completed / rated to map individual trajectories, enabling individual gains to be measured. Suggested outcome measures: Social skills measure: Social skills rating scale (SSRS) with parent, teacher and self-reports versions available (see Gresham & Elliott, 1990). Items on each scale are rated according to perceived frequency and importance - a feature unique to the SSRS. This scale will need to be purchased. Distributors already contacted. • Social Skills Scale measures positive social behaviours: Cooperation, Empathy, Assertion, Self-Control and Responsibility.

- Problem Behaviours Scale measures behaviours that can interfere with the development of positive social skills. It assesses behaviour in three subscales: Externalizing Problems, such as aggressive acts and poor temper control, Internalizing Problems, such as sadness and anxiety and Hyperactivity, such as fidgeting and impulsive acts.
- Academic Competence Scale provides a quick estimate of academic functioning. Teachers rate reading and mathematics performance, general cognitive functioning, as well as motivation and parental support.

The strengths and difficulties questionnaire is a brief behavioural screening questionnaire which produces scores on five scales and a total difficulties score (see Goodman, 1997; Goodman *et al.*, 1998). Parent, teacher and adolescent self-report versions are available.
- http://www.sdqinfo.com/b2.html

The child global assessment scale (Schaffer *et al.*, 1983) is a clinician rated scale that provides a global measure of level of functioning in children and adolescents.
- http://www.health.nsw.gov.au/policy/cmh/mhoat/outcome_measures/cgasv1.pdf

Self-descriptions to provide more individually tailored measures:
- Simplified personal questionnaire (Elliott, Mack & Shapiro)
- http://www.experiential-researchers.org/instruments/elliott/pqprocedure.html

Possibly use a parent-rated social skills questionnaire to gauge the frequency of particular behaviours, this scale was adapted for ASD by Dr Nick Wood and colleagues for a previously run social skills group. This is not a standardised measure and compatibility with the suggested data analysis would need to be determined.

Evaluation form designed to gain qualitative feedback from both parents and the young people themselves about the group.

An appropriate standardised measure to assess the self-esteem is still to be decided.
- Possibly the Rosenberg self-esteem scale
- http://eib.emcdda.europa.eu/html.cfm/index3676EN.html

Q17	**Participants: recruitment methods, age, gender, exclusion/inclusion criteria:**
	The 'robot club' will be run within an existing voluntary agency for young people with an ASD and their families called the 'St Nicholas Academy for Autism Project' (SNAAP). Families will initially be approached by the SNAAP staff to register whether they are interested in the group and whether they wish to be contacted by the researcher. In order to be eligible, the young people with need to have a diagnosis of high-functioning autism or AS. The young people who attend SNAAP tend to range in age from 8-14years, with the average age of 10-years. All ages will be eligible for the 'robot club'. Both boys and girls will be eligible.

	Participants and researcher will meet prior to the group starting to explain the study, gain consent from the parents/carers and the young people themselves and complete a set of outcome measures to act as baseline measurements.
Q18	**Consent and participant information arrangements, debriefing:** There is no need to deceive participants and their families about the nature of the study so full information will be able to be provided. Therefore informed consent will be sought. Written information will be provided to all families who express an interest in the club and written consent will be sought. The meetings set up between the families and the researcher will allow for the young people and their families to ask any questions they might have. All completed outcome measures will be kept in a locked cabinet with only the anonymous scores being transported and used in the study. All information will therefore remain anonymous. The completed outcome measures will be destroyed after completion of the study. Due to there being no deception, specific de-briefing will not be necessary regarding the nature of the study. However, meetings will again take place with each young person and their family to complete the post group outcome measures. During this time further discussion about the study and/or specific questions the families might have can be answered. It is hoped that if timing allows that a follow up meeting could take place to complete a second set of post group outcome measures to see if the young people have maintained any improvements made during the course of the club. This will again allow the young people and their families to ask any further questions and to discuss the findings. The researchers contact details will be given to families so if they have any questions at any other time, they will be able to ask.
Q19	**Any other relevant information:** Although this study involves working with young people under the age of 18-years who have social and communication difficulties, this study does not raise any significant ethical implications. Due to the age range of the young people that usually attend SNAAP, it will be necessary to gain consent to participate from parents/carers, however it should also be possible to gain approval for participation from the young people themselves. It will be important to make it clear that participation is voluntary and that they can remove their consent to participate at any time. The anticipated time taken to complete each outcome measure has been taken into account when selecting appropriate self-report measures. This enables the level of stress on the young people and their families participating in the study to be kept to a minimum, as well as facilitating likeliness to participate. The number of measures, their

length and those specifically to be completed after each group session has therefore been thought about carefully to keep the time taken to complete them to a minimum.

The group aims to be a fun experience for the children and their families and will enable them to learn about robots and to meet other people with similar difficulties. The club will take place in a venue they are already familiar which will reduce any anxiety that the young people may have felt about being somewhere new. The outcome measures do not ask about difficult topics and therefore there is no anticipation that they could prove distressing. However, all the young people and families who participate will already be members of SNAAP and have access to support from the staff if necessary.

Although not participating in the actual sessions, the young peoples parents/carers will be present in the room whilst the group takes place and whilst the young people complete the outcome measures. This will allow them to talk with other parents and to keep an eye on their children from a distance. This should also help alleviate any anxieties that the young people or their parents have about attending the club. Therefore, if by chance someone did become distressed, their parent/carer would be able to be notified immediately and able to comfort them as necessary.

Although all information collected during the course of the study will remain confidential, in the unlikely event of a concerning disclosure from a young person or their family, it may be necessary to break that confidentiality in order make sure that the risk is minimised. Families will be made aware of the limits of confidentiality and will be advised of the appropriate action to take. It may be necessary to make a referral to family GPs in order to access support for the young person and/or their family outside of the family unit and the SNAAP volunteers.

If able, we are keen to video record the sessions in order to provide an opportunity to double check any observations made during the course of each session. This will allow a second observer to note difficulties and improvements and therefore improve observer-reliability and the quality of the data collected though observation. As with the outcome measures, all video data will be kept in a locked cabinet in the SNAAP rooms will be destroyed once the study has been completed. These will only be viewed by those involved in the research. Parents/carers and the young people themselves will also be asked specifically if they are happy for still images to be included in the write up as pictures can not remain anonymous in the same way as written information. Images will not be used if consent is not given. Video recordings were made of the previous running of the club and consent was given for stills to be used by the families involved.

This study is linked in with the AuRoRa project within the school of computer science (University of Hertfordshire) which has been granted ethical approval within the above school. I have been registered as another researcher with this project, see protocol number 0809/03.

PLEAE TICK **EITHER** _BOX A_ **OR** _BOX B_ BELOW AND PROVIDE RELEVANT ADDITIONAL INFORMATION IF YOU TICK **BOX B**. THEN PASS THE FORM TO YOUR SUPERVISOR

Please tick

A. I consider that this project has **no** significant ethical implications to be brought before the Psychology Ethics Committee.	
B. I consider that this project **may** have ethical implications that should be brought before the Psychology Ethics Committee	✓

Please provide a clear but concise statement of the ethical considerations raised by the project and how you intend to deal with them.
If a YES answer has been given to any of the questions 8-12 above, please state previous experience of the supervisor, or academic staff applying for a standard protocol, of investigations causing hazards, risks, discomfort or distress. If it is likely that medical or other aftercare may be needed by participants, please, indicate who will provide the aftercare, and whether they have confirmed that the aftercare can be provided free of charge to the participants.
Main ethical concerns relate to the age of the participants and the difficulties associated with their diagnosis of high-functioning autism or Asperger's syndrome. Possible concerns have been considered and appropriate measures have been included in the design of the study, including the limits of confidentiality if a risky disclosure is made. Please see answer to question 19 for more details.

This form (and all attachments) should be submitted (via your Supervisor for MSc/BSc students) to the Psychology Ethics Committee, psyethics@herts.ac.uk where it will be reviewed before it can be approved.

I confirm I am familiar with the BPS Guidelines for ethical practices in psychological research.

Name: Sarah Blank   Date:
(Researcher(s))

Name: Dr Nick Wood   Date:
(Supervisor)

CHECKLIST FOR REQUIRED APPENDICES (appended at the end of this form)
1. YOUR CONSENT FORM **– attached below**
2. YOUR INFORMATION SHEET **– attached below**
3. YOUR DEBRIEF SHEET **N/A**
4. QUESTIONNAIRE(S) IF USED **– parent-rated questionnaire and example evaluation form attached below**
Online links provided within Q16 for the following:
• SDQ, CGAS, Simplified personal questionnaire, Rosenberg self-esteem scale
SSRS due to be purchased, sample not available
5. SAMPLE MATERIAL(S) USED (e.g., pictures, stories, etc) **N/A**
6. LETTERS TO HEADTEACHERS (if the study is conducted in schools) **N/A**
7. A SAMPLE LETTER TO PARENTS (if the study is conducted in schools) **N/A**

<div style="border: 1px solid black;">

SCHOOL OF PSYCHOLOGY ETHICS APPLICATION FORM - 3

For minor modifications to an existing protocol approval

</div>

Status: Doctorate in Clinical Psychology

Course code (if student): DClinPsy (Student Number: 06129561)

Title of project: The Robot Club: Using robots as agents to improve social skills for young people on the autistic spectrum

Name of researcher(s): Sarah Blank

Contact Tel. no: 07879 638 636
Contact Email: S.T.Blank@herts.ac.uk

Name of supervisor: Primary Supervisor - Dr Nick Wood
Secondary Supervisor - Dr Ben Robins

Start Date of Study (if the end date of the existing approval has expired)**:**

End Date of Study: September 2009 (viva date)

Details of modification: To improve the design of the study by adding a comparative control group. Families who do not wish to participate in the actual Robot Club, but who are interested in the study will be approached to form a comparative control group. This would require completion of the same questionnaires as those attending the group, at the beginning and end of the overall programme, without actually attending the group. This addition of a comparative control group should improve the strength of the study to detect real effects and thus to further strengthen the ethics of participation. The same risk and confidentiality provision will apply as for the other participants and if treatment is found to be effective, their potential to participate in future groups will be discussed.

The following paragraph will be added to the information sheet for parents and teachers:

"If you are interested in this study but are not sure about actually attending the 'Robot Club', I am also interested in families forming a control group so I can compare the answers given on the questionnaires by those attending the club, to those who don't. If you and your family decide to take part in the control group you would need to complete the questionnaires at the beginning and end of the overall programme, but would not actually attend the club itself. As mentioned above, all information would be kept confidential unless something that was particularly worrying was discussed, in which case we would first discuss this with you and if necessary seek agreement to inform an appropriate other

person."

The following point will be added to the consent form:
"I have read all the information provided and I give my full consent for my family to take part in the study and to join the control group. I understand that this means that my child will not be attending the Robot Club, but that if it is found to be effective we will be informed and considered for future groups."

Does the modification present additional hazards to the participant/investigator? *(delete an inappropriate option category)*	NO
If yes, please provide a clear but concise statement of the ethical considerations raised by the project and how you intend to deal with them.	YES

This form should be submitted (via your Supervisor for MSc/BSc students) to the Psychology Ethics Committee, psyethics@herts.ac.uk where it will be reviewed before being approved by chair's action.

PLEASE ATTACH COPY OF ORIGINAL PROTOCOL APPLICATION

Name: Sarah Blank   Date: 21st November 2008
(Researcher(s))

Name: Dr Nick Wood   Date: 21st November 2008
(Supervisor)

APPROVAL OF PROTOCOL APPLICATION FOR MODIFICATION

We support the approval of modification of the above protocol	✕
We **do not** support the modification of the above protocol for the following reasons:	

Signature:

Nicholas Troop   **Date: 26th November 2008**

SCHOOL OF PSYCHOLOGY ETHICS COMMITTEE APPROVAL

Student Investigator: Sarah Blank

Title of project: The Robot Club: Using robots as agents to improve social skills for young people on the autistic spectrum

Supervisor: Nick Wood

Registration Protocol Number: PSY/11/08/SB

The approval for the above research project was granted on 27 November 2008 by the Psychology Ethics Committee under delegated authority from the Ethics Committee of the University of Hertfordshire.

Signed: **Date**: 27 November 2008

Dr. Nick Troop
Chair
Psychology Ethics Committee

STATEMENT OF THE SUPERVISOR:

From my discussions with the above student, as far as I can ascertain, s/he has followed the ethics protocol approved for this project.

Signed (supervisor): ....

Date: 30/9/09

Appendix F: Histograms depicting the baseline scores for the GARS-2 for the whole sample

Mean =92.5
Std. Dev. =19.744
N =10

Mean =9
Std. Dev. =3.197
N =10

Mean =8.7
Std. Dev. =3.268
N =10

Baseline Communication score on the GARS-2

Mean =8.9
Std. Dev. =3.281
N =10

Baseline Social Interaction score on the GARS-2
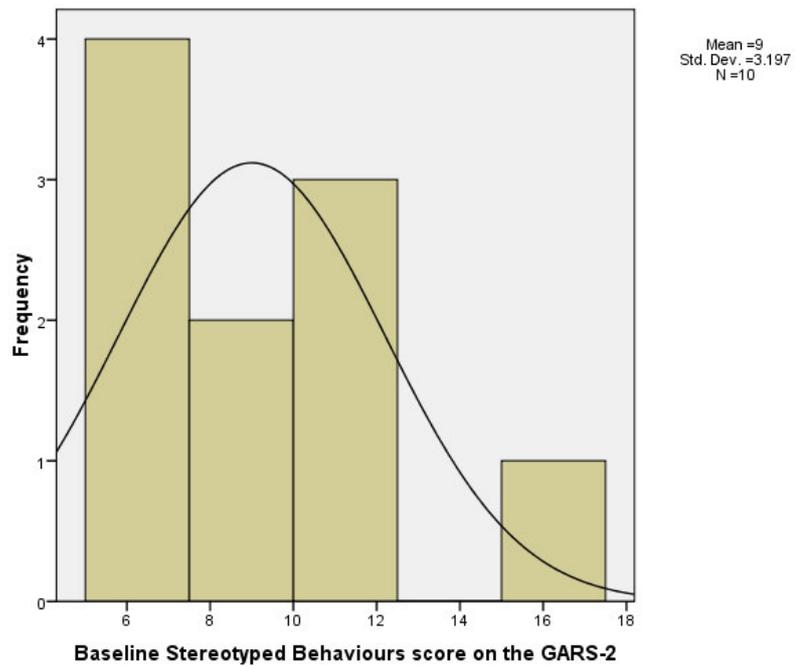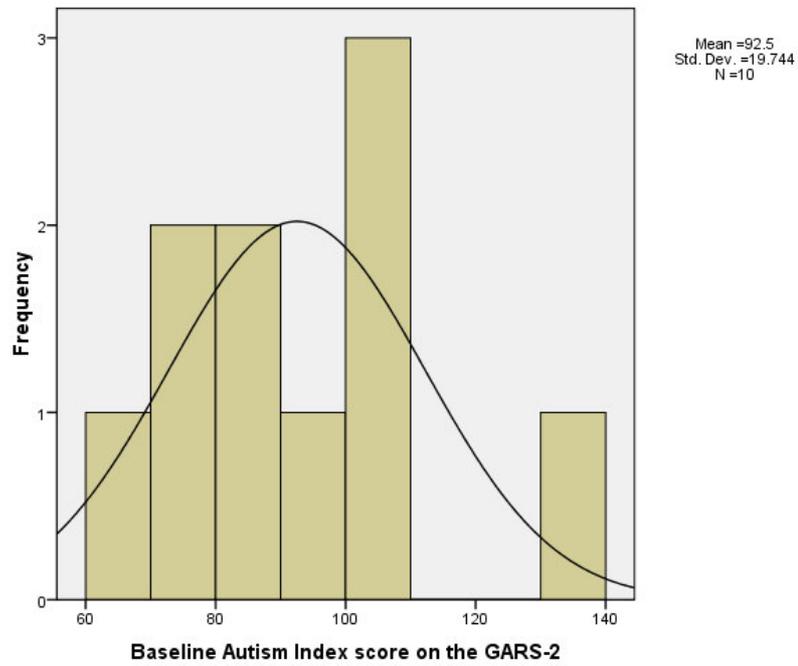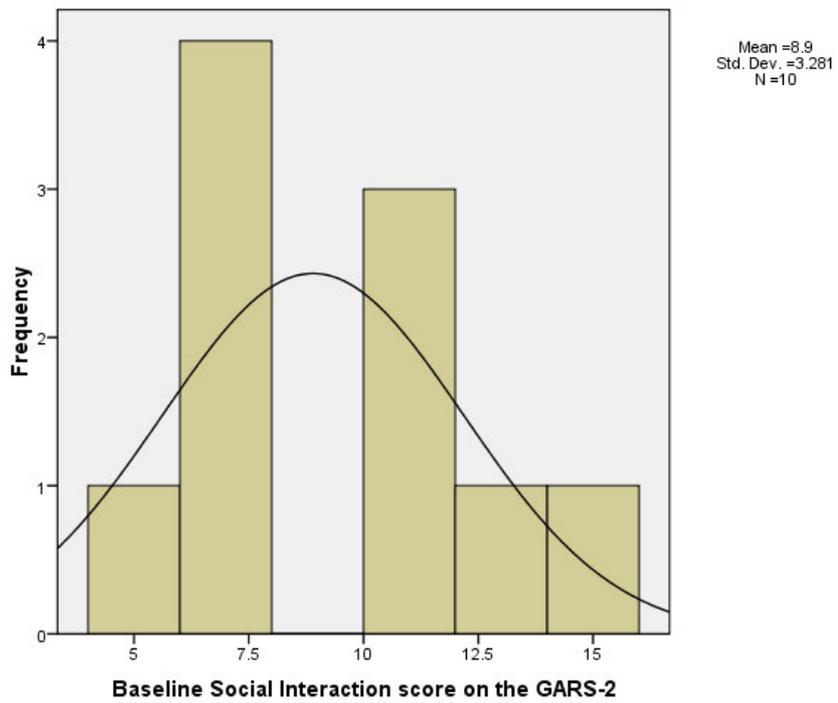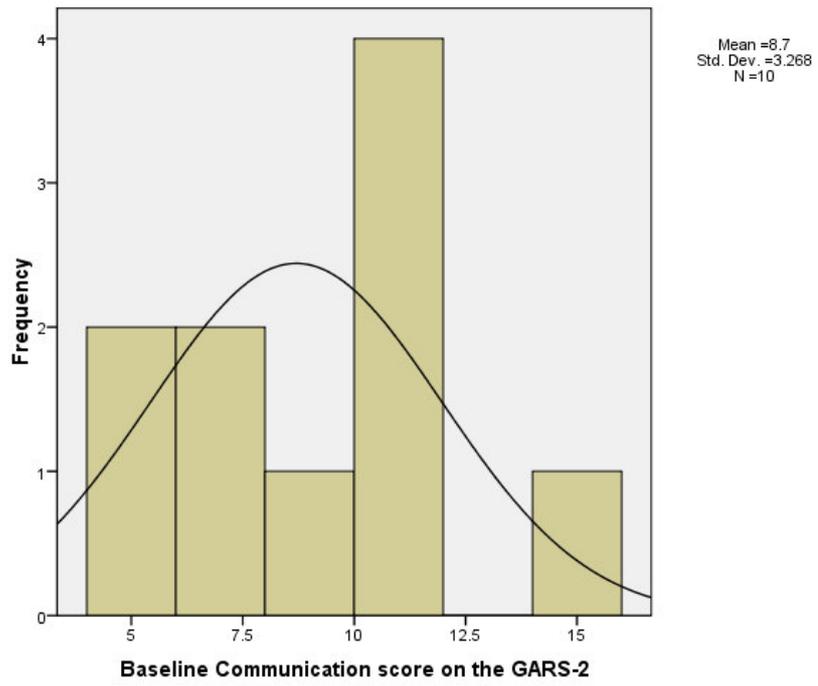
Box plots depicting the distribution for the GARS-2 per session for the whole sample

Autism Index for the GARS-2 per session

Stereotyped Behaviours for the GARS-2 per session

Communication for the GARS-2 per session

Social Interaction for the GARS-2 per session
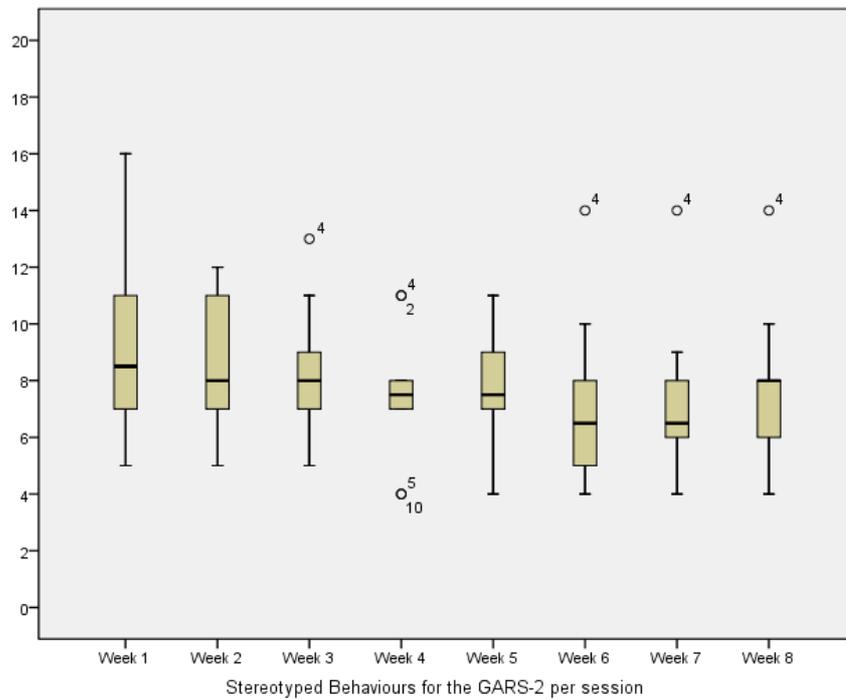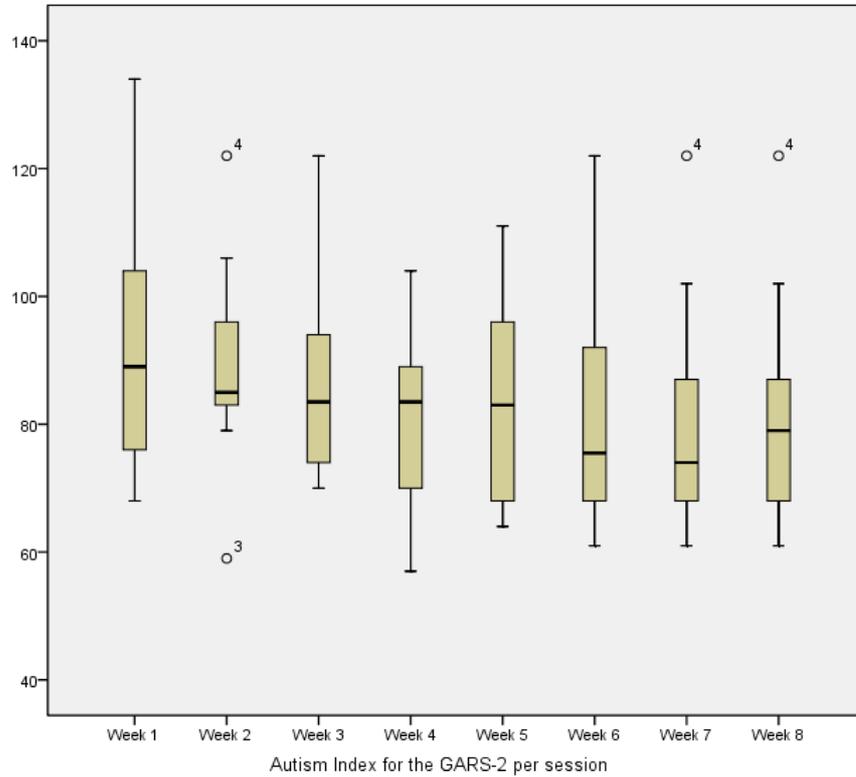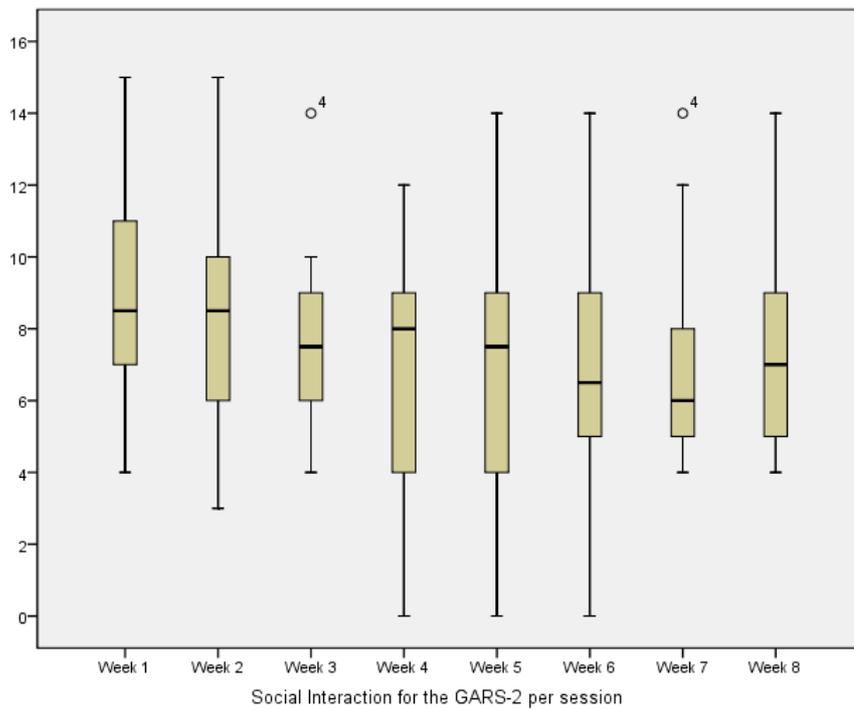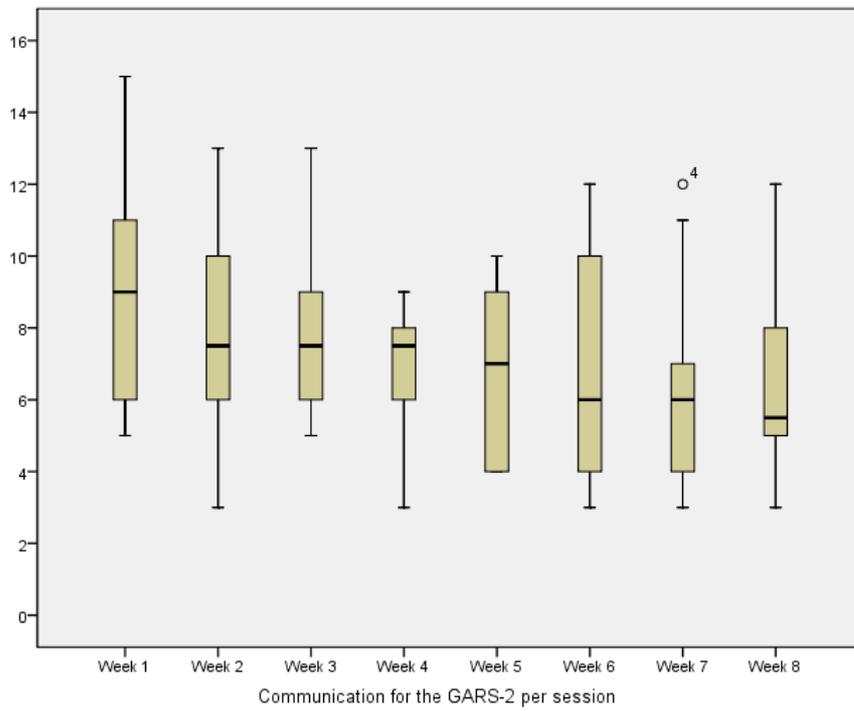
Box plot depicting the gain scores for the GARS-2 for the whole sample
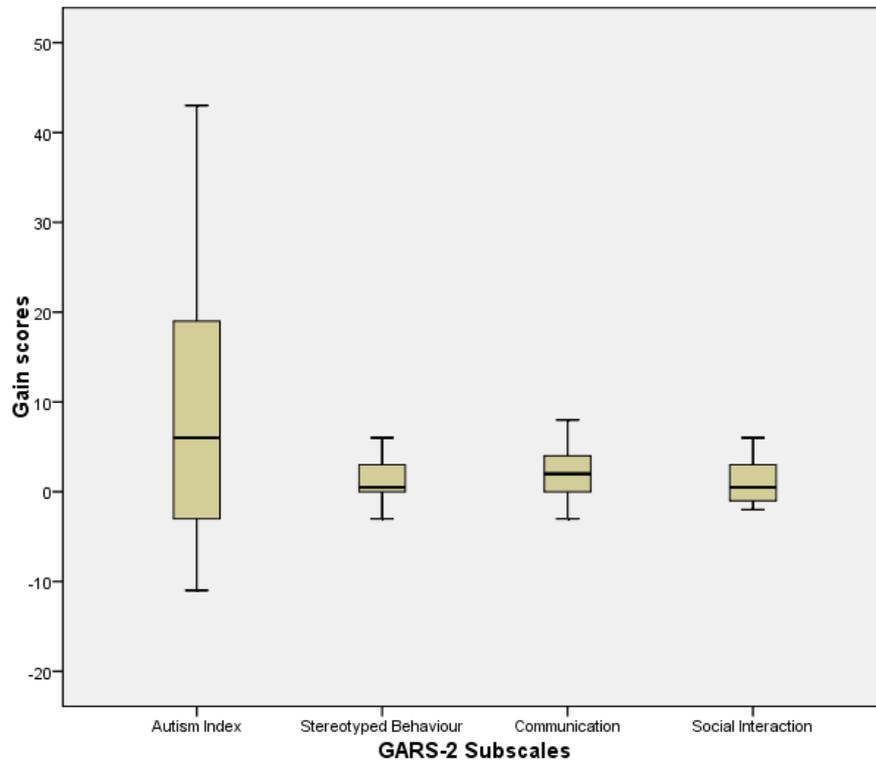
Appendix G: Box plots depicting the distribution for the SSIS, SDQ, behaviour checklist and CGAS for the whole sample

SSIS

SDQ

Parent rated SDQ Impact



Self-rated SDQ subscales
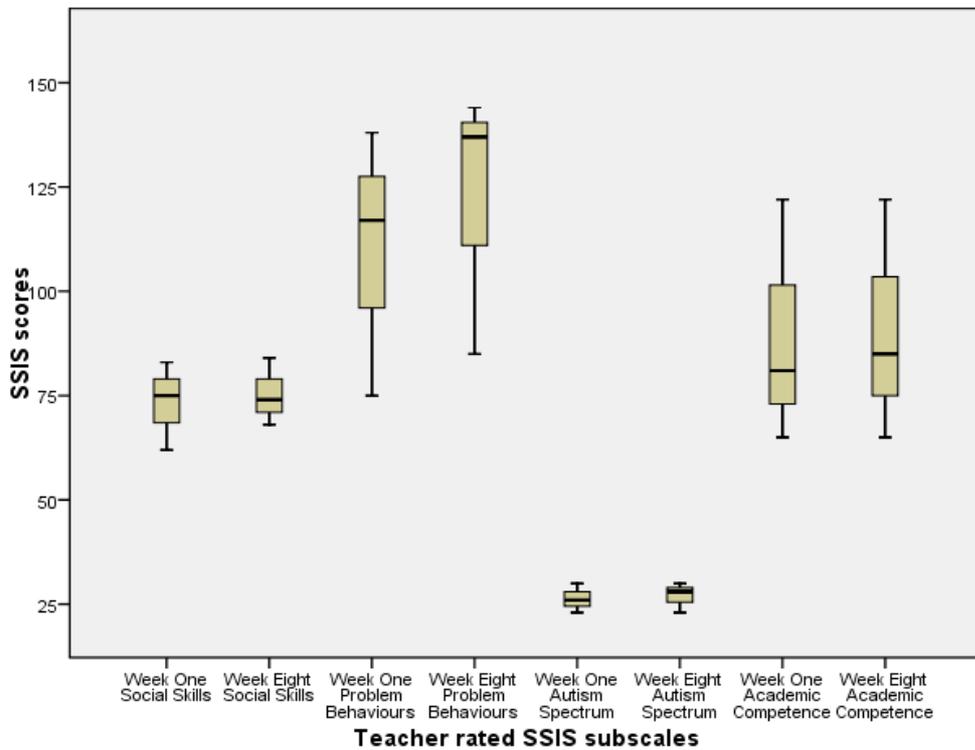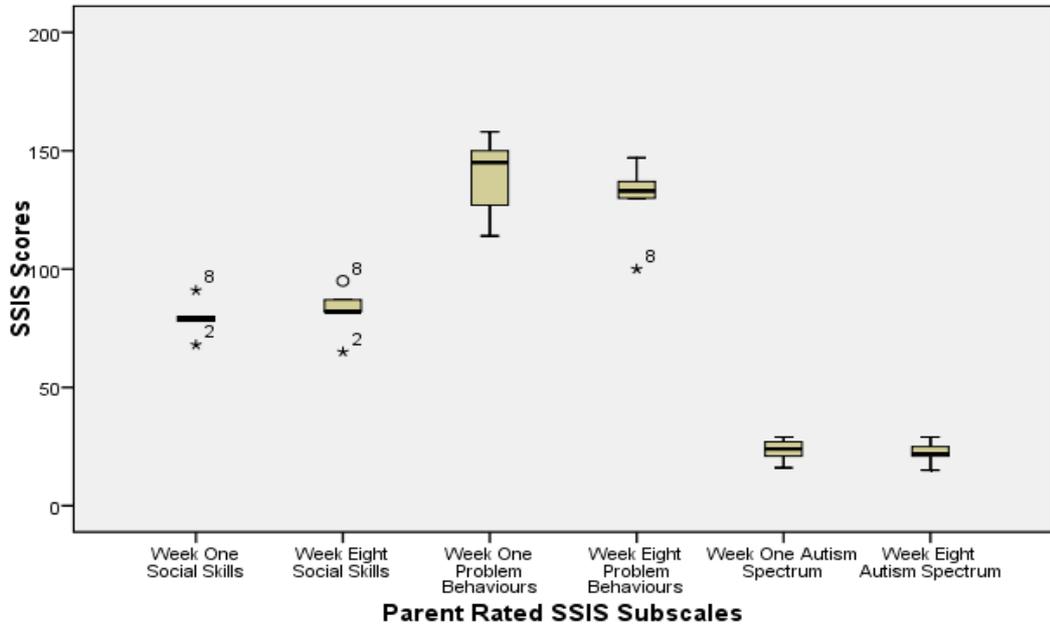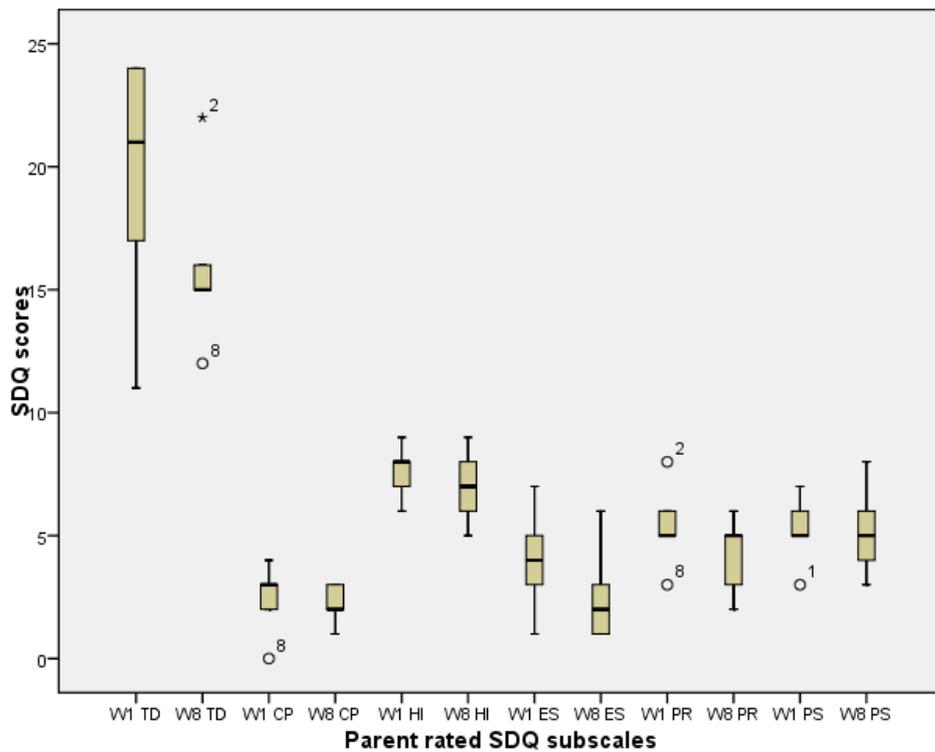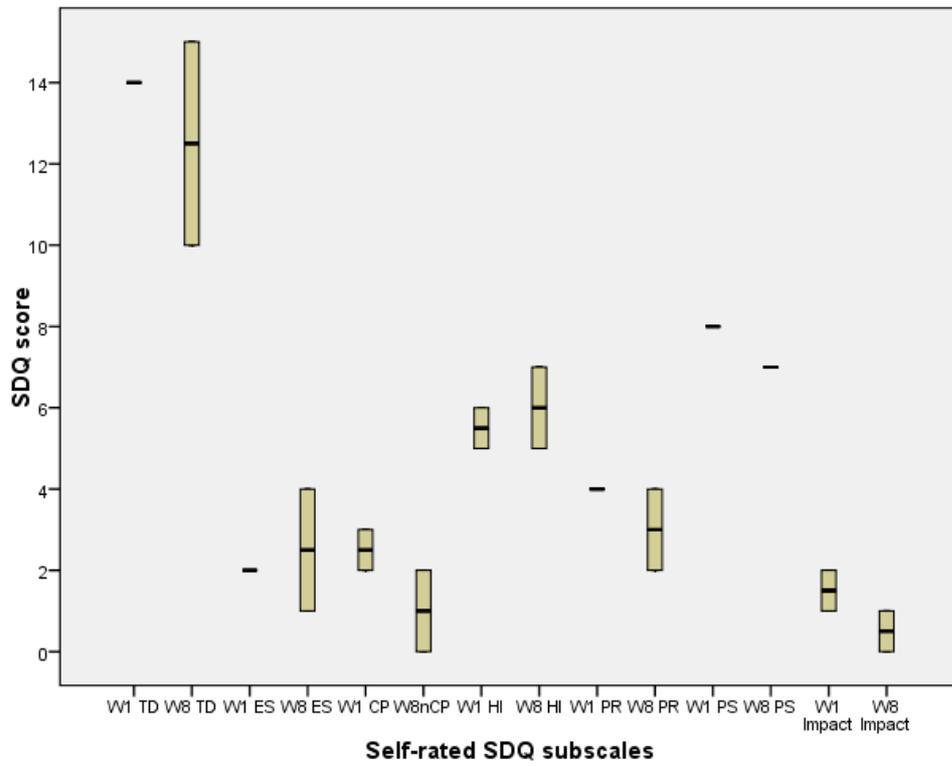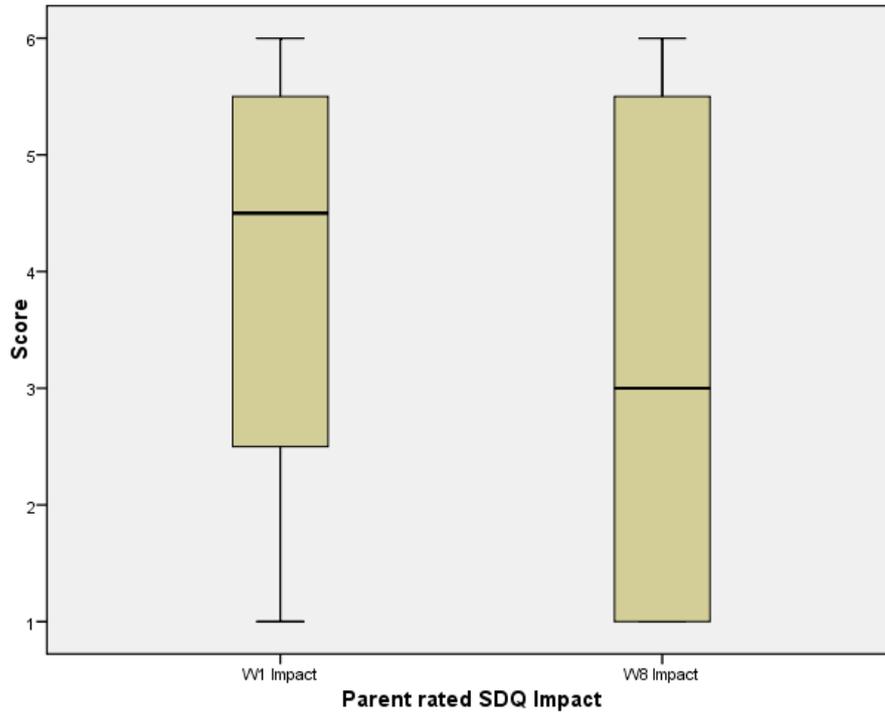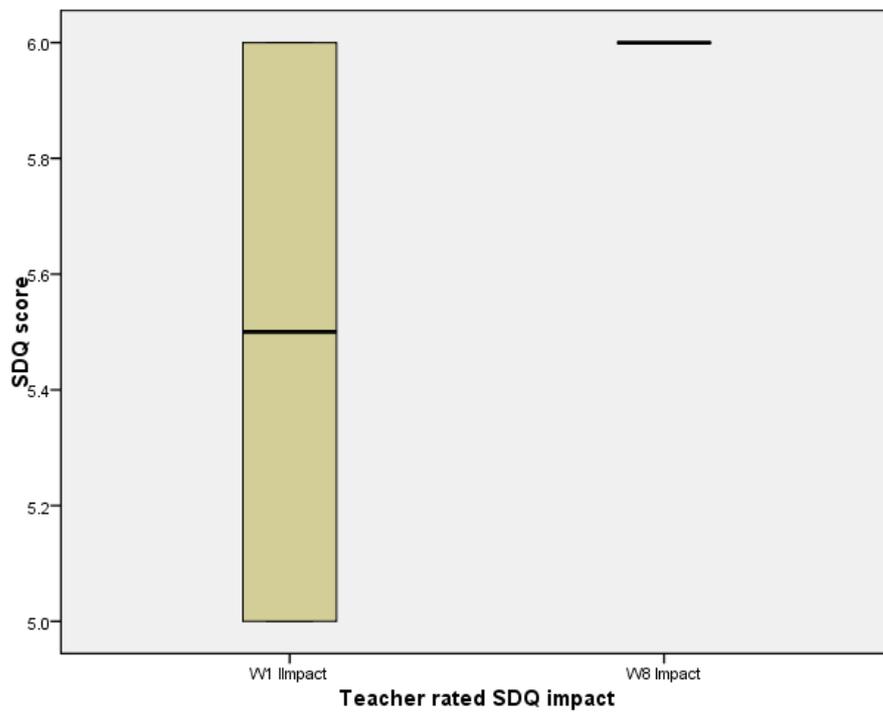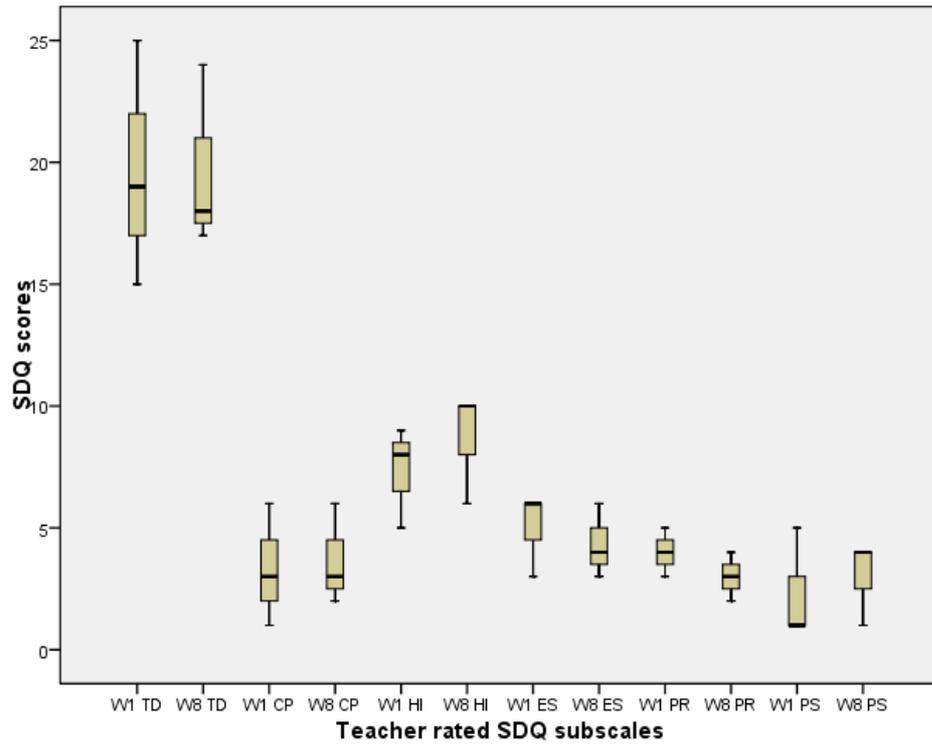
Parent rated behaviour checklist
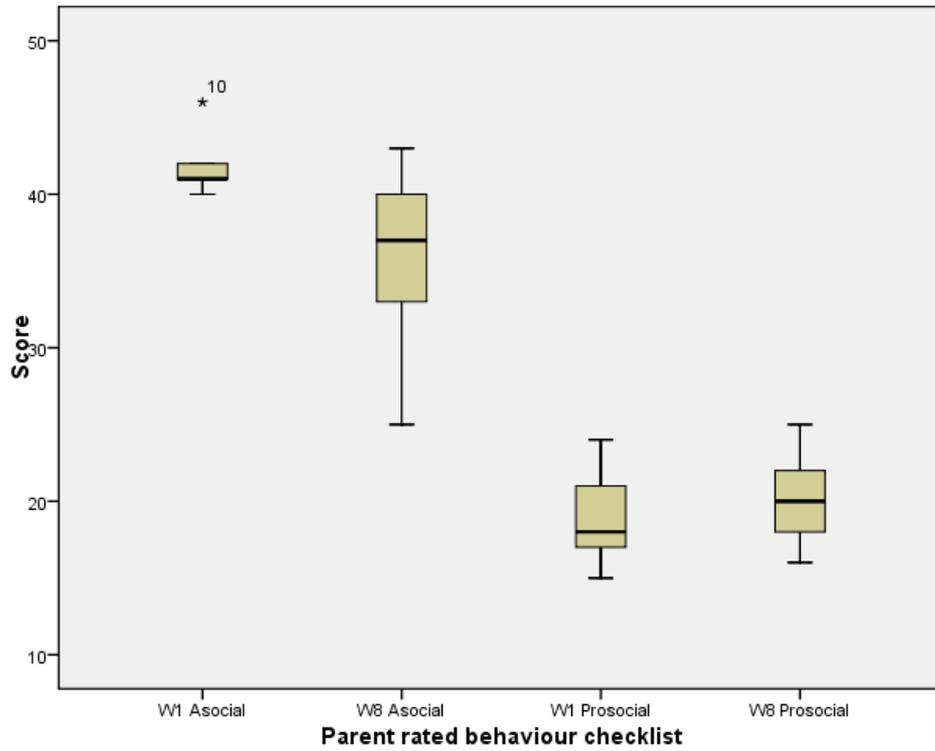
CGAS
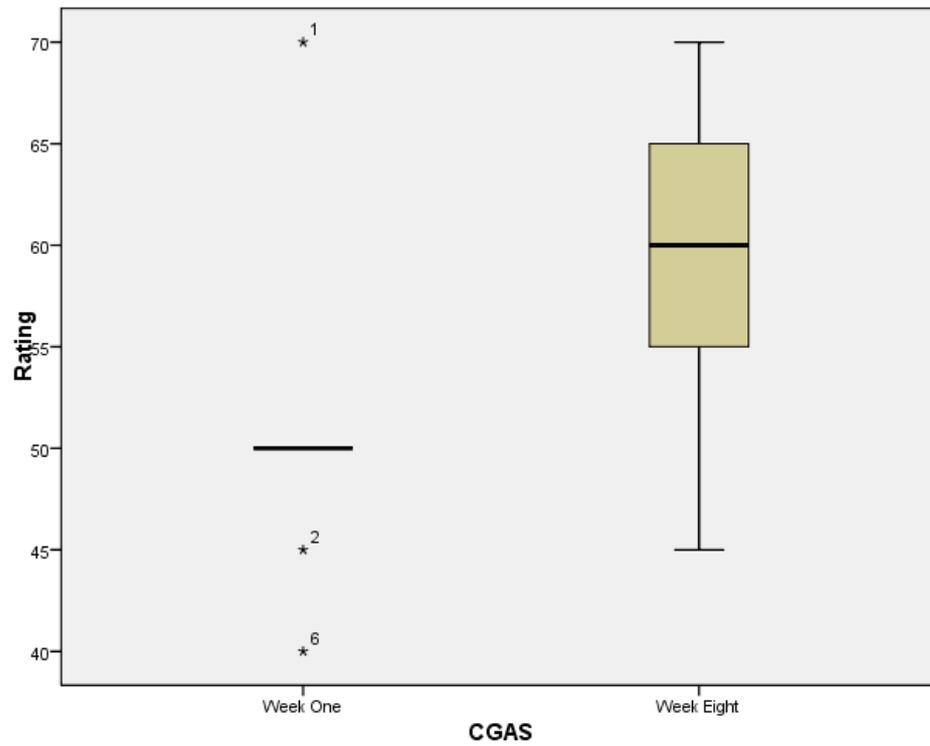
Appendix H: Line graphs of ratings for goal based outcomes for each participant

Participant 1

Participant 2

Participant 7

Participant 8

Participant 9

Participant 10