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Abstract

Reports reveal various benefits of animals - especially dogs - for children with Autism Spectrum disorders (ASD). However, not all children with ASD display the same interest in animals. Dogs are the most common species within family households and the only species to be used as service animals. They are also the most commonly used species in animal assisted interventions. Despite the key role that both the interest and the behaviours displayed towards dogs might play in their benefits to children with ASD, no studies have yet investigated this aspect using direct observation. Applying an ethological approach, this study aimed to explore and characterize how children with ASD interact with a service dog during a first encounter. Video recordings of 20 children with ASD in free interactions during their first encounter with a service dog were analyzed. Our results indicate that children with ASD are attracted to service dogs, but we found important interindividual variations. We distinguished two main behavioural interaction profiles (one more distal with the service dog, and the other more proximal and attracted to the service dog). Our results show that the children with ASD's interaction strategies vary according to their age and ASD severity: younger children made fewer physical contacts with the service dog, gazed less at it and displayed less care behaviours, while children with severer ASD seemed to rely on a smaller behavioural repertoire when interacting with a service dog. This study is the first to characterise how children with ASD interact with a service dog during their first encounter. These findings open onto future research concerning the importance of a child with ASD's attraction to and behaviour in the presence of an animal, as well as of the impacts of a child's characteristics (i.e., age, ASD severity, and sensory processing disorder) to be able to improve programmes for animal-assisted interventions.

Introduction

Autism spectrum disorder (ASD) is a complex and heterogeneous neurodevelopmental condition characterized by impairment of communication skills, alteration of social interactions, and restricted and repetitive interests and behaviours (DSM-5; American Psychiatric Association 2013; Christensen et al., 2018; McDougall et al., 2018). Many therapeutic strategies have been developed to improve the daily living and social interactions of individual with ASD (Hume et al., 2021; McConell, 2002; Will et al., 12018; Wong et al., 2015; Wong and Smith, 2006) including alternative intervention strategies with animals (Grandgeorge and Hausberger, 2011). Since the first reports by Levinson (1962) and by Redefer and Goodman (1989), animal assisted interventions (AAI) have been popularized and largely used. Numerous studies have focused on this specific topic and they demonstrate the multiple beneficial impacts of interactions with animals on children with ASD and their contribution to their socio-emotional development (e.g., Berry et al., 2013; Carlisle, 2012, 2015; Carlisle et al., 2018, 2020; Grandgeorge, 2015; Grandgeorge and Hausberger, 2011; Sprod and Norwood, 2017; Viau et al., 2010; Wright et al., 2016a). Reports on the effects of the addition of an animal to the therapeutic setting confirm that the presence of an animal facilitates interactions with a therapist, increases children with ASD's social interactions and prosocial behaviours during a session, reduces their stress, anxiety and the expression of negative behaviours; improvement of the children's language, communication and social skills can also be observed (Ávila-Álvarez et al., 2019; Funahashi et al., 2014; Martin and Farnum, 2002; O'Haire, 2013; O'Haire et al., 2013, 2014; 2015; Sams et al., 2006; Silva et al., 2011). Alternatively, studies investigating the effects of the presence of an animal in a child with ASD's daily life, either a pet (mostly cats and dogs) or a service dog, demonstrate multiple benefits for children with ASD: improvement of their social, language and

communication skills, increase in their social reciprocity and prosocial behaviours, improvement of their general mood, emotional regulation and adaptability, and at the same time decrease of problematic behaviours (e.g., bolting, outbursts, tantrum, aggression), stress/anxiety and depression (Bibbo et al., 2019 ; Brown, 2017; Carlisle, 2012, 2015; Grandgeorge et al., 2012a; Hall et al., 2016a,b; Hoffman, 2011; Sprod and Norwood, 2017; Viau et al., 2010; Ward et al., 2017; Wild, 2012; Wright et al., 2015, 2016a, 2016b).

Authors have hypothesized that these benefits originate from the fact that animals constitute an adequate interaction partner for children with ASD (Grandgeorge, 2015; Grandgeorge et al., 2016; Martin and Farnum, 2002; Maurer et al., 2011). It is supposed that animals' behaviours could be easier to decode and less ambiguous for individuals with ASD, compared with those of human partners, since animals' behaviours would be more predictable and less complex for individuals with ASD (Redefer and Goodman, 1989; Prothmann et al, 2009). Furthermore, compared with humans, animals rely on other sensory modalities to interact (i.e., non-verbal communication and tactile contact) and have the advantage of being less sensitive to the respect of social norms of interaction (Leslie, 1994; Martin et Farnum, 2002; Maurer et al., 2011; Redefer et Goodman, 1989).

In line with this hypothesis, studies provide elements confirming that impairments and deficits in social interactions related to ASD could be specific to human stimuli and that interacting with an animal might rely on strategies and processes that are not altered by ASD; this could explain why animals might assume a specific status for children with ASD (Atherton and Cross, 2018, 2019; Grandgeorge et al., 2016; Maurer et al., 2011).

Indeed, most children with ASD are spontaneously interested in and attracted to animals (Carlisle, 2015; Celani, 2002; Grandgeorge et al., 2012a, 2012b; Martin and Farnum, 2002; O'Haire et al., 2013; Prothmann et al., 2009). Attraction to, and interest in animals have been confirmed by eye-tracking studies (Amestoy, 2013; Dollion et al., 2021). Moreover, while individuals with ASD classically present a deficit in exploration of the eye area of human faces (Pelphrey et al., 2002; Tanaka & Sung, 2016), this deficit is not observed for animal faces (i.e., they look significantly longer at the eye area than at the mouth area; Grandgeorge et al, 2016). This specificity of the processing of animal faces is corroborated by fMRI data on high functioning adolescents with ASD (Whyte et al., 2016). Recent studies suggest that these specificities could extend to complex social skills, such as the theory of mind (Atherton and Cross, 2018; 2019; Cross et al., 2019). Through their interactions with animals, children with ASD might thus practice and develop various social skills that they could generalize and transfer to interactions with human agents subsequently (Filiâtre et al., 1986; Grandgeorge, 2020; Grandgeorge et al., 2012a; Harwood et al., 2019).

Thus, children with ASD's interest in animals and the specificities of their interactions with animals could be at the core of benefits. The biophilia hypothesis leads to the assumption that all human beings, including individuals with ASD, are naturally interested and attracted to nature and animals (Kahn, 1997; Wilson, 1984). However, although the literature demonstrates that children with ASD show spontaneous interest in animals (Grandgeorge et al., 2014; Prothmann et al., 2009) and are able to develop a privileged relationship with them, interindividual variations exist; some children with ASD express no interest in animals and/or develop no relationship with them (Carlisle, 2012, 2014, 2015; Carlisle et al., 2020; Grandgeorge et al., 2012a; Harwood et al.,

2019). As the general population (Kidd and Kidd, 1987), not all children with ASD like or desire to interact with animals. Moreover, some children with ASD might be attracted to, as well as inclined to interact and bond with certain species more than others (e.g., cat versus dog) (Carlisle et al., 2018; Grandgeorge, 2020; Guérin et al., 2017; Harwood et al., 2019), while others may be scarred or have animal phobias (Carlisle, 2014; Mayes et al., 2013). Furthermore, parental interviews indicate that some parents are concerned about their children with ASD's behaviours and the dog's safety and welfare (Burrows et al., 2008; Carlisle, 2014, 2015; Carlisle et al., 2018, 2020; Hall et al., 2019; Harwood et al., 2019). Some parents also worry that the animal, and especially some of its behaviours (e.g., bark, lick, unpredicted reaction...) could be a source of irritation for their child with ASD, and thus could lead to avoidance and/or to an exacerbation of their issues (i.e., auditory sensitivity, tactile sensitivity, need for predictability...) (Carlisle et al., 2018, 2020).

To date, only one research team has investigated the behavioural profiles displayed during interactions in close-to-life-conditions using direct observations to characterize how children with ASD interact with an unfamiliar animal (i.e., a guinea pig) (Grandgeorge et al., 2012b, 2014). These authors identified three distinct behavioural profiles: confident (child approaches quickly the animal and touches it), human-directed (child turns towards adults and talks to the animal without touching it), and self-centred (child expresses self-centred gestures and stereotypies, makes no contact with the animal). Dogs are the most common pet species in the households of families of children with ASD, as well as one of the most commonly used species in animal assisted interventions (AAI) and the only species currently used as service animal for children with ASD (Carlisle, 2015; Grandgeorge and Hausberger, 2011). Despite the depicted variations in

interest and behavioural profiles during interactions with an animal, and the possible impacts of interactions with an animal on the benefits and relationship with that animal, no study has yet investigated how children with ASD interact with a service dog. Therefore, the present study aimed to explore and characterize the first encounter between children with ASD and service dogs. More specifically, two main questions were investigated in this study concerning: (1) the variations in behavioural strategies observed in the way children with ASD interact during their first encounter with a service dog; (2) the impact of factors, such as age, presence of sensory processing disorders and ASD severity on the behaviours displayed by children with ASD during their first encounter with a service dog. Since ASD phenotypes can differ in relation to sex (Lai et al., 2011, Mclennan et al., 1993; Rubenstein et al., 2015), and interactions of neurotypical (NT) children with an unfamiliar animal can also differ according to sex (Grandgeorge et al., 2011; 2012b), we also investigated the impact of this variable.

Material and methods

Participants

Ethics

The protocol of the present study was approved by the ethic committee of research in arts and sciences (CERAS) of the University of Montréal (project number: CERAS2018-19_111-P). This study was based on non-invasive observations and was performed in line with the principles of the Declaration of Helsinki revised in 2000. All observations in the present study consist of recordings performed between 2012 and 2014 by the Mira Foundation (www.mira.ca) during the first evaluation of candidate families for a Mira service dog for children with ASD. Parents provided an initial written consent to perform these recordings and provided an additional written consent for

the use of the recordings for the present research. All children with ASD also provided their verbal assent.

Human participants

Potential participants meeting the enrolment criteria for the present study were drawn from the database of the Mira Foundation. The inclusion criteria were established as followed: the child must have had an ASD diagnostic, have a full recording of his/her first evaluation at the Mira Foundation, must be visible on the video for at least 50% of the total time he/she was exposed to the service dog during the evaluation, and must not have previously been the recipient of a service dog. Twenty Canadian children with ASD (16 boys and 4 girls), all aged between 3 and 12 years old (mean age 8.6±2.7 years old) at the time of observation, participated in this study. Characterization of ASD was made at the time of evaluation by a professional from the Mira Foundation (i.e., psychoeducator, psychologist, educational psychologist) using the Child Autism Rating Scale (CARS, Scholpler et al., 1980; French version, Rogé, 1989). All participants had a low to moderate severity score of ASD (i.e., mean CARS score 28.2±4.4). Information relative to participant's comorbidities was gathered through consultation of the clinical records sent by the families to the Mira Foundation. Seventeen participants presented comorbidities and 15 had tactile sensory processing disorders (see Table 1).

[*insert Table 1 here*]

Service dog participants

Eighteen service dogs bred and trained by the Mira Foundation were involved (13 males and 5 females; mean age 21.7±2.9 months old) (Table 1). All were at the end of their

training and were to be certified soon after the recordings (for more details see Dollion et al., 2019). Eight were Labrador, 3 were Labernese and 7 were Saint-Pierre. All, except four of our participants, with ASD, met a different service dog. As two of the children with ASD were observed within the same week, the same service dog was used during those observations (i.e., participants 2-7 and 16-17 in Table 1).

Experimental design

Prior to the admittance of a potential beneficiary into the programme "service dog for children with ASD", every family had to send a full clinical record confirming their child's diagnosis of ASD and had to undergo a standardized evaluation at the Mira Foundation. All evaluations were conducted in a room dedicated to observation of children with ASD and were performed by a professional from the Mira foundation (i.e., evaluator). This room was equipped to receive children with ASD and contained age-adapted material, toys and games. The room was also equipped with a video surveillance system allowing recording of the situation through a large angle video camera (700TVL H-Bird II, Monoprice). All evaluations followed a standardized procedure: (a) first, the child with ASD and his/her parent(s) were left for 20 minutes of free play in the room ; (b) the service dog was introduced to the child with ASD and his/her family by the evaluator; (c) the evaluator left the room and the service dog, the child with ASD and his/her parent(s) were left for 10 minutes of free interaction; (d) the evaluator re-entered the room and explained the commands the service dog responds to (i.e., sit, down, stay, come, heel), and also introduced objects to use with the service dog (i.e., bowl, dry food, brush); (e) the evaluator left the room and the family was again left for 10 additional minutes of free interaction with the service dog; (f) the parent(s) was/were interviewed by the evaluator in order to establish what were the

difficulties, strengths and needs of the child with ASD. When the evaluator was not in the room he/she observed the child with ASD through a one-way mirror from an adjacent room (see Figure 1 for a representation of the evaluation room). Following the evaluation, the evaluator completed the CARS based on his/her observation of the child with ASD and on the parent(s)' interview.

[*insert Figure 1 here*]

Data collection and analyses

Data collection

Scores on the CARS completed by the evaluator for each child, as well as the video recordings of their evaluation were retrieved from the database of the Mira Foundation. The behavioural coding of video-recordings was performed using The Observer XT software (version 11.0, Noldus, Netherlands). Recordings were analyzed using ethological methods of data sampling (Altmann, 1974). Behavioural coding was performed only for the 20-minute period of free interaction with the service dog (i.e. phases c and e detailed above). Scan sampling (at 10-second intervals) and focal sampling techniques were used to code various behavioural items reflecting a child's interactions with the service dog (see Table 2 for details of the behavioural repertoire; more detailed information relative to the behavioural coding and behavioural definitions are available online, see supplemental file 1).

[*insert Table 2 here*]

During the evaluation, a child with ASD could be accompanied either by one or both of his/her parents and sometimes his/her sibling(s). When more than one parent was present, the parent who shared the closest physical contact and who interacted the most with the

child with ASD was considered as the *Primary caregiver*. The other parent and the sibling(s) were considered as a group called *Secondary caregiver*. Only the primary caregiver was considered when evaluating distances to parent. However, both parents were considered for coding other behavioural variables (i.e., gazes and vocalizations).

All coding of behaviours expressed by participants during the observations was performed by the same rater (AH). For reliability purposes, another rater (ND) coded 15% of the recordings, selected randomly. As confirmed by Cohen's Kappa, the inter-rater reliability was excellent (mean Kappa index across all behaviours of 0.83).

Since the camera could not cover the entire room, only visible behaviours were coded. All periods when both the child and the dog were in the same part of the room with all or a part of their bodies non-visible were considered as non-visible and thus non-codable (i.e., mean non-visible period of 6.0±9.1% of the total durations of the coded sequences). Due to interindividual variability in duration of phases of free interaction with the service dog and of "codable" periods (mean duration of codable free interaction: 16.5±1.7 minutes), the codable times and occurrences were reproportioned over 20 minutes for all individuals prior to analyses.

The presence or absence of tactile sensory processing disorders (i.e., hyper- or hyposensitivity) was extracted based on consultation of the full medical record transmitted by families to the Mira Foundation as well as on parents answers during the interview with the evaluator (i.e. the interview included questions related to the presence/absence of hyper/hyposensitivity).

Statistical analyses

Since our data did not fit a normal distribution, nonparametric statistical tests were applied (Siegel & Castellan 1988). Statistica 13rd edition and IBM SPSS Statistics software were used to perform statistical analyses. Significance threshold was p=0.05. Friedman and Wilcoxon Signed Rank tests were used to compare dependent samples (e.g., the difference in behaviours among the same group) with application of the Bonferroni correction. Spearman tests were used to evaluate the correlations between behaviours and (1) children with ASD's age and (2) ASD severity (score of CARS). Mann-Whitney tests were applied to test differences in behaviours displayed between (1) hypo- and hyper-sensitive children with ASD, and (2) boys and girls. Due to technical issues, the video recordings of four children did not include an audio recording. Missing values for vocalizations for these children were handled through mean imputation of missing values. A Hierarchical Ascending Classification (HAC) based on Ward distances was performed to determine whether groups of children with ASD could be distinguished based on behavioural variables. Comparisons between these groups were computed using Mann-Whitney tests.

Results

Description of displayed behaviours during the encounter

Children with ASD and service dogs were in physical contact (i.e. including direct and indirect contacts) approximately 20% of the time (Table 3), but total durations of physical contacts varied greatly among participants (mean duration of physical contact: $M \pm SD$ = 249.9±187.1s; range: 43.3-615.2s). Physical contacts were initiated

more by the children than by the service dogs ($Z = 3.72$, $p < 0.001$) or the parents ($Z = 3.72$, $p < 0.001$).

[*insert Table 3 here*]

When physical contact occurred, direct physical contact (i.e., "skin to skin") was 5 times more frequent than indirect physical contact (i.e., with an object) ($Z = 3.17$, $p = 0.0015$). Interestingly, only a few inappropriate physical contacts were observed, as for instance, a child with ASD's head on the dog's tail (n = 2 children, less than 3 times during each encounter) or a child's foot on the dog's paw (n = 1 child, observed only once).

 Interestingly, the preferred distance with the service dog did not seem to be either direct or indirect physical contact, but rather close to the dog, i.e. at 0–½ arm length ($2.7 \leq Z \geq 3.9$, all $p < 0.01$). Children with ASD were observed less frequently at 1–1.5 arm length than at 0.5-1 arm length from the service dog ($Z = 3.8$, $p < 0.001$). Physical contact with parents (i.e. direct and indirect) was the rarest position from parents observed (all $Z \geq 3.9$, all $p < 0.001$), followed by 1-1.5 arm distance ($2.6 \leq Z \geq 3.9$, all $p < 0.01$). Children with ASD spent significantly more time in contact with the service dog than with their parent ($Z = 3.7$, $p < 0.001$) and significantly more time at more than 1.5 arm distance from their parent than from the service dog ($Z = 2.8$, $p = 0.005$).

With important interindividual variations, children with ASD frequently emitted vocalizations about (i.e., addressed to parent(s)) and towards the service dog. Approximately 4 of 5 vocalizations were directed to the service dog (compared with parents, $Z = 3.36$, $p = 0.001$). The main type of vocalizations (approximately 45%) was "service dog

commands" (e.g., "sit down") compared with the other types of vocalizations ($3.2 \leq Z \geq 3.5$, all $p \leq 0.001$) expect neutral vocalizations (i.e., "others", $Z = 1.3$, $p > 0.05$). Attraction vocalizations were more frequent than rejection vocalizations ($Z = 3.4$, $p < 0.001$). Here again, with important interindividual variations, children with ASD displayed frequent gestures towards the service dog during their first encounter. The main type of gesture (around 70%) was "service dog commands" (all $Z \geq 3.5$, all $p < 0.001$). Although differences were not significant, children with ASD tended to display more rejection gestures than attraction gestures towards the service dog ($Z = 1.57$, $p = 0.11$). More than a half of the children's gazes were oriented towards the service dog. They gazed more at the service dog than at all the other visual targets (all $Z \geq 3.4$, all $p \leq 0.001$), and they gazed more at "other" stimuli in the visual scene than at their parents ($Z = 3.1$, $p = 0.002$). No significant differences could be observed between children's gazes at objects and toys and their gazes at their parents ($Z = 0.5$, $p > 0.05$).

Care behaviours were observed around a quarter of time during the encounter. None of the care behaviours was expressed significantly more than any other. Non-adapted care was almost absent during observations: one child used the treat box to attract the service dog's attention by shaking it.

Parameters influencing behaviours displayed during the interaction

Although the overall behavioural trends were consistent, interindividual variability was important. We analysed the potential effects of age, gender, ASD severity and hypo-/hypersensitivity on the variability of the children with ASD's behaviours (Table 3). Only statistically significant results are reported below.

The older the children with ASD were, (1) the more time they spent in physical contact with the service dog ($r_s = 0.602$, $p = 0.005$), (2) the more they initiated physical contacts with it (duration $r_s = 0.603$, $p = 0.005$), (3) the more they made direct physical contact with it (duration $r_s = 0.677$, in % $r_s = 0.666$, both tests $p < 0.01$), (4) the less they remained far from it (more than 1.5 arm length, $r_s = -0.639$, $p = 0.001$) and (5) the more they were far from their parents (more than 1.5 arm length, $r_s = 0.496$, $p = 0.03$). The older the children were, (1) the more they gazed at the service dog ($r_s = 0.768$, $p < 0.001$) and (2) the less they gazed at objects and toys ($r_s = -0.644$, $p = 0.002$). The older the children were, the more they displayed care behaviours ($r_s = -0.597$, $p = 0.005$) and the more they gave treats to the service dog ($r_s = 0.465$, $p = 0.04$).

Only a few correlations between children's CARS scores and behavioural items were observed. The higher the children's CARS scores were, (1) the less they were in indirect contact with the dog (in duration, $r_s = -0.445$, $p = 0.049$) and (2) the less they expressed neutral types of vocalizations (i.e., vocalizations other than name, command, attraction or rejection) ($r_s = -0.644$, $p = 0.007$).

Children with tactile hypersensitivity ($n = 8$) spent more time in contact with a service dog (Mann-Whitney U test, $U = 8$, $p = 0.02$), were more frequently in contact with a service dog ($U = 10$, p $= 0.04$) and less frequently at 1.5 arm length from it ($U = 1$, $p = 0.002$), compared with children with tactile hyposensitivity ($n = 7$). Although only marginally significant, children with hypersensitivity tended to spend more time in contact

with the service dog (U = 12, p = 0.06), especially when they had initiated contact (U = 12, p = 0.06) and less time at 1 arm length from it (U = 12, p = 0.06).

No significant differences according to sex could be evidenced, except that girls spent less time in contact with a dog when contact was initiated by their parent than did boys (U = 12, p = 0.04).

Profiles of interaction with a service dog

Applying Hierarchical Ascending Classification analysis, we explored differences of behavioural profiles of children with ASD when interacting with a service dog. Two groups emerged from this analysis. Both groups differed significantly on part of the collected behavioural variables (Table 3).

The first group (n = 13) included children who were more frequently far from the service dog (i.e. at 1, 1.5 arm length and more), who gazed more at objects and toys as well as at the rest of the visual scene (i.e. "other") and who tended to make more attempts of contact with the service dog. Children in the second group (n = 7) spent more time in contact with the service dog, established more direct contacts with it, were more at the initiation of those contacts, gazed more at the dog as well at their parent(s), were more frequently further from their parent, displayed more attraction gestures towards the service dog, and brushed it more frequently. The first group was thus labelled the "more distal with the service dog" group. The second group was labelled the "more proximal and attracted to the service dog" group.

Since both children's age and ASD severity seemed to have an effect on the behaviours displayed during the interaction with the service dog, we compared these variables between groups. No significant differences could be evidenced between groups for scores on CARS ($U = 36$, $p > 0.05$). However, children's ages differed significantly ($U = 19$, $p = 0.039$). Children in the "more distal with the service dog" group were significantly younger than children in the "more proximal and attracted to the service dog" group (mean age 7.6±2.7 and 10.4±1.7 years old, respectively). No significant differences related to hypo-/hypersensitivity were observed.

Discussion

The present study investigated interactions with a service dog during the first encounter of 20 children selected for attribution of a service dog. This study is the first to explore and characterize how children with ASD interact with a service dog. Our results highlight the presence of a general interest and interaction pattern but with important interindividual variations. By analysing the behaviours displayed by our sample of children with ASD we were able to distinguish two behavioural profiles of interaction (proximal and attracted to the service dog; more distal with the service dog). Variations in behavioural strategies and profiles during interactions with a service dog related to children with ASD's age were observed. Variations related to ASD severity and sensory processing disorder were also observed.

General pattern of children with ASD's interactions with a service dog

The 20 children with ASD observed in the present study were generally attracted to the service dog, as they spent most of the experimental observation time either in physical contact with the service dog or close to it. They preferred to be in contact with the service dog more than with their parents from whom they stayed at a greater distance. Furthermore, they were generally the initiators of contacts with the service dog and this latter was the preferential target of their gazes during observations. These results are in line with previous reports demonstrating that children with ASD are attracted to animals (Amestoy, 2013; Celani, 2002; Dollion et al., 2021; Grandgeorge et al., 2014; 2020; Prothmann et al., 2009; Valiyamattam et al., 2020).

Previous studies reported parental concerns concerning children with ASD's safety and adequacy/appropriateness of behaviours towards animals (Bergstrom et al. 2011; Burrows et al., 2008; Calisle, 2014; Carlisle et al., 2018, 2020; Hall et al., 2017, 2019; Harwood et al., 2019). Nevertheless, during the present study we observed no violent or harmful behaviours, as well as no behaviours risking compromising the dog's safety or wellbeing. Only three children with ASD displayed what we classified as non-adapted contacts, corresponding to unusual contacts with the service dog, and one child with ASD expressed what we classified as non-adapted care when he distorted the usage of the treat box by shaking it to attract the service dog's attention. Rather than contradicting previous reports and the great caution that should be given to these behaviours, the present observations (i.e., on 20 children with ASD selected for attribution of a service dog) support existing reports indicating that most children with ASD do not display these types behaviours with animals (Carlisle, 2012; Carlisle et al., 2020).

Commands were the most displayed behaviours by children with ASD addressed both vocally and gesturally towards the service dog. The demonstration by the evaluator and their parent's encouragements to emit commands may have encouraged these children with ASD to express this type of behaviour. Furthermore, apart from the fact that giving commands to the service dog is common in the context of interactions with a dog, we cannot exclude the fact that the positive feedback that the child with ASD could receive from the service dog obeying a command and displaying the expected behaviour may have reinforced this behaviour and its expression by the child with ASD (Endenburg and Baarda, 1995). Numerous neutral vocalizations to, or concerning the service dog were emitted during our observations. Similar results were reported by Martin and Farnum (2002): when exposed to a dog, children with ASD were more likely to talk about and to the dog than when exposed to other stimuli (i.e., ball or stuffed dog). Grandgeorge et al. (2014) reported that the quantity of vocalizations displayed towards a pet (i.e., a guinea pig) did not differ between children with and without ASD during free interaction with the pet.

The 20 observed children with ASD in our study emitted more attraction than rejection vocalizations while no significant differences were observed concerning the number of attraction and rejection gestures. When expressed, rejection behaviours corresponded mainly to reactions to unwanted contacts initiated by the dog (as for instance when a service dog licked (or tried to) the child with ASD's face) and/or avoidance of contact with the dog's mouth. Sensory processing disorders associated with ASD may have contributed to these behaviours (e.g., avoidance of physical contact or of contact with the service dog's saliva) (Carlisle, 2012, 2014; Carlisle et al., 2018). Furthermore, children with ASD might avoid and/or be reluctant to come into contact with the service

dog's head due to fear of being bitten (Carlisle, 2014). In agreement with Filiatre et al.'s (1986) observations of NT children, we observed that contacts with the service dog initiated by the children with ASD were longer than contacts initiated by the service dog itself or by the parent. Children with ASD's need for predictability may have contributed to this result (Redefer and Goodman, 1989; Prothmann et al., 2009). The shorter duration for contacts initiated by parents seems to echo Grandgeorge et al.'s (2017) study using the social rivalry situation. In this study children with ASD displayed more behaviours oriented towards the dog and more physical interventions towards the dog-dog's trainer dyad when the dog trainer stopped actively trying to involve the child with ASD in the interaction and reoriented his/her attention away from him/her.

More generally, our data concerning the 20 children with ASD observed in the present study while interacting with a service dog revealed that these children displayed a wide range of behaviours involving various modalities (e.g., gestures, vocalizations, gazes, physical contacts). Thus, their interactions with a service dog, as with other animals (Grandgeorge et al., 2012a, 2014; Hart el., 2018; Talarovičová, 2010), seem to be multimodal by essence. Rather than contradicting directly Redefer and Goodman's (1989) hypothesis, according to which children with ASD would prefer to interact with animals because of the non-verbal nature of interactions with them and their reliance on other sensory modalities, our observations encourage the idea that this could be more a matter of relative balance of reliance on the different sensory modalities (i.e., less reliance on verbal communication even if present).

Influence of different factors on children with ASD's interactions with a service dog

Although we observed a general pattern of interaction with a service dog, we found important interindividual variations among the children with ASD in the present study (i.e. 20 individuals selected for attribution of a service dog), and this can be explained by the influence of several parameters. First, age had a significant influence, as younger children with ASD made fewer physical contacts with a service dog, gave it less treats, gazed less at it and were further from it and nearer from their parent(s) than older children with ASD. This result seems in opposition to previous reports demonstrating that younger NT children rely more on physical interaction with an animal compared with older children who rely more on vocal interaction (Eckerlin et al., 1989; Mertens & Turner, 1988). However, during a first interaction with an unfamiliar animal, older NT and ASD children interacted and made contact more easily with a guinea pig than did younger children (Grandgeorge et al., 2011, 2012 b). Older children with ASD might have benefited from more previous experiences of interactions with other animals, like other dogs, which could facilitate interactions with an unknown dog (Coltea, 2011; Grandgeorge et al., 2012b, 2014; 2016; Hall et al., 2016b). The development of children with ASD's social and communication skills as they grow may also contribute to this influence of age (Anderson et al., 2009; Freeman et al., 1999; McGovern & Sigman, 2005). This could allow them to rely on a more adapted behavioural repertoire during interactions with animals, as observed in NT children (Filiatre et al., 1986; Millot et al., 1988; Morrongiello et al., 2007).

We found a significant correlation between ASD symptom severity and interaction with a service dog: children with ASD with higher scores on CARS expressed fewer neutral

vocalizations and made less indirect contacts with the dog. Although this result may be surprising, it might reflect the fact that children with higher ASD severity rely on a smaller behavioural repertoire when interacting with a service dog. This interpretation would be in line with Grandgeorge et al.'s (2014) previous observations showing that children with ASD's interaction behaviours with an animal varied in relation to their verbal language level. In their study on families of children with ASD, Hall et al. (2016b) demonstrated that the efficacy of dog ownership varied according to individual parameters, and notably, the child with ASD's language and disability levels. It would thus be of interest for future studies to investigate in more detail the impact of ASD severity and symptoms on child-dog interactions and on the benefits of exposure to animals.

Our results highlight the fact that children with ASD with hypersensitivity tended to make more physical contacts with a service dog than did children with ASD with hyposensitivity. Contrarily to our current observations, previous authors suggested that hypersensitivity would lead to avoidance of social situations in order to avoid sensory overload (e.g., Pickard et al., 2020). Parents also report their concerns about their children with ASD's hypersensitivity in relation to the inclusion of an animal in the family household (e.g., Carlisle, 2012, 2014). However, children with ASD with hypersensitivity, notably tactile, may favour contact with specific textures such as soft materials (Christopher, 2019). In our case, it would seem that the increased contacts with a service dog made by children with ASD with hypersensitivity might reflect the fact that they enjoyed the sensation of touching a service dog's soft fur. As these preliminary results (i.e., collected on 20 children selected for attribution of a service dog) are intriguing,

further studies need to investigate the impact of sensory processing disorders on inter-

actions with an animal.

Different profiles of interaction with a service dog

Our cluster analysis on the interaction behaviours displayed by a small group of 20

children with ASD revealed two behavioural profiles of interaction. The first profile,

"more distal with the service dog" ($n = 13$), included children with ASD who were less

in contact with the service dog, initiated less contacts with it, gazed less at it and re-

mained more frequently at some distance from it. The second profile, "more proximal

and attracted to the service dog" ($n = 7$), included children with ASD who were more

frequently in contact with the service dog (notably direct contacts), initiated more con-

tacts with it, gazed more at it, displayed more attraction gesture and care behaviours

towards it (notably brushed the service dog). Interestingly, in line with the association

between age and behaviours with the service dog previously mentioned (i.e. younger

children with ASD were less frequently in contact with service dog, stayed further away

from it and looked at it less frequently); children with ASD with the "more distal with

the service dog" profile were significantly younger (mean age 7.6±2.7 years old) than

children with ASD with the "more proximal and attracted to the service dog" profile

(mean age 10.4±1.7 years old).

We also noted that the children with ASD who were more in physical interaction with

the service dog (i.e., more proximal and attracted to the service dog group) also gazed

more at their parent(s) than did the children in the other group. Social referencing refers

to the process by which a child might gather information (i.e., evaluation cues) from

another individual in order to dissipate the ambiguity of a new or unclear situation (Planche, 2010). Children with ASD have been previously reported to display this type of behaviour in the context of an encounter with an unfamiliar animal (Grandgeorge et al., 2012b). Our present result could indicate that social referencing to parents might contribute to enhance children with ASD's easiness to interact with a service dog.

It is important to note that our cluster analysis was performed on a small sample (i.e. 20 children with ASD selected for attribution of a service dog). The differentiated groups may thus not be representative of what would be observed in the general ASD population. Nonetheless, the behavioural variability observed and the fact that we could distinguish two groups of children with ASD indicate that all children with ASD do not display the same profiles and behavioural strategies when interacting for the first time with a service dog.

Using an ethological approach to characterize the behavioural profiles displayed by children with ASD during their first encounter with an unfamiliar animal Grandgeorge et al. (2012b) described three behavioural profiles: confident (child approached the animal quickly and touched it), human-directed (child turned towards adults and talked to the animal but did not touch it), and self-centred (child displayed self-centred gestures and stereotypies, but did not make contact with the animal). This dichotomy between confident and human-directed profiles appears similar to the two profiles defined in the present study: some children with ASD preferred to make physical contact with the service dog whereas others preferred to remain at a certain distance from it.

More generally, our exploratory study conducted on 20 children with ASD selected for attribution of a service dog and observed during their first encounter with a service dog highlighted the presence of variations among children with ASD concerning their attraction and attitude towards a service dog, and analyses of these variations enabled us to evidence different interaction strategies and behavioural profiles. Thus, contrarily to expectations based on previous studies (Prothmann et al., 2009; Redefer and Goodman, 1989), all children with ASD do not display the same interest in animals and some, as indicated by some authors (e.g., Carlisle, 2014; Carlisle et al., 2020; Grandgeorge et al., 2012a), may display less or no interest in them. Furthermore, when attracted, children with ASD may rely on different behavioural strategies to interact with a service dog (i.e., physical contact *versus* vocalizations and gestures). Our results also strengthen the importance of considering children with ASD's characteristics (i.e., age, ASD severity) in future studies, since they seem to influence children with ASD's attraction and behavioural strategies with animals. Additionally, in line with previous authors reporting impacts of children with ASD's age of the arrival of an animal in their family household on the benefits they could gain (e.g., Grandgeorge et al. 2012a; 2012b) and on variations of children with ASD's ability to develop a privileged relationship with their family pet, as well as parental concerns for the animal's safety (Carlisle, 2014; Carlisle et al., 2020), the present results highlight the fact that considering these parameters (i.e., child age and ASD severity), as well as observing the child with ASD during interactions with an animal (i.e., his/her attraction to the animal and interaction behaviours) could be of importance for professionals, since it may help orient their decision to integrate or not an animal in that family, as well as for pairing a child with ASD with an animal (i.e., to choose an animal in relation to its personality profile that will be suited for the child).

Limitations and perspectives

For ethical reasons, only families of children with ASD selected for the attribution of a Mira service dog were invited to participate in this study. Thus, the participants were children with ASD who had been evaluated as having pertinent needs and as being sufficiently attracted to dogs for attribution of a service dog. The interindividual variability in attraction to service dogs and in displayed behaviours might have thus been lessened. Similarly, the range of ASD severity of children that participated in the present study was relatively narrow (i.e., low to moderate severity). Replication of this study with a larger range of children with ASD, without prior selection, should yield data more representative of the ASD population.

The fact that our sample of children with ASD was relatively small could also have lessened the incidence of some parameters due to the small numbers of participants in our subgroups. It may also lessen the possibility to extend our conclusions to the general population of children with ASD. Furthermore, some parameters known to affect children with ASD's interactions with animals were not collected in the present study (e.g., presence of animals at home, previous experience with animals, activities with animals) (Coltea, 2011; Grandgeorge et al., 2012; 2014; 2016; Hall et al., 2016b). Replicating this study with a larger sample including collection of additional information relative to the children with ASD's experience with animals would be of interest. Furthermore, the Mira Foundation's standard procedure for evaluation of candidate families still uses the first version of the CARS. In the present study, we took the opportunity of this data collection by the Mira foundation to gather information allowing characterisation of our

participants. It would however be of interest for future studies to consider using an updated version of this tool (i.e., CARS-2) that would be more adapted to the evaluation of children with ASD's cognitive traits.

Although we performed these observations in a controlled situation (i.e., standard evaluation procedure and controlled environment), we cannot exclude the fact that variations in numbers of parents and siblings present during observations could have influenced participants' behaviours (e.g., access to objects, talking to the child). In addition, observations in controlled situations are never fully representative of real life. It would thus be relevant if in the future similar studies were performed in real life situations.

Previous studies demonstrated that children with ASD can bond significantly with animals other than dogs, such as cats, and benefit from their relationship with them (Carlisle, 2020; Grandgeorge et al., 2020; Hart et al., 2018). Future studies should explore how children with ASD adapt their interaction strategies according to the species and to their interest in that species. It would also be an opportunity to further the investigation of the impacts of animal familiarity and past experience with animals. Additionally, although the present results allowed us to define how children with ASD interact with a service dog, it would be of interest for future studies to compare their behaviour with that of a control group of NT children, as did Grandgeorge et al. (2012b), or to investigate if children with ASD display the same behavioural tendencies when of interacting with a robot or a stuffed animal (Martin & Farnum, 2002; Silva et al., 2018).

Acknowledgments

Conflicts Interests

The authors have no conflicts of interest to declare relevant to the contents of this article.

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FIGURES AND TABLES

Figure captions

Figure 1: The evaluation room and its adjacent observation compartment: 1) observation compartment, 2) evaluation room, a) one-way mirror, b) surveillance video camera, c) games and toys, d) child-size table with four chairs, e) child foam mats.

Figures

Figure 1:
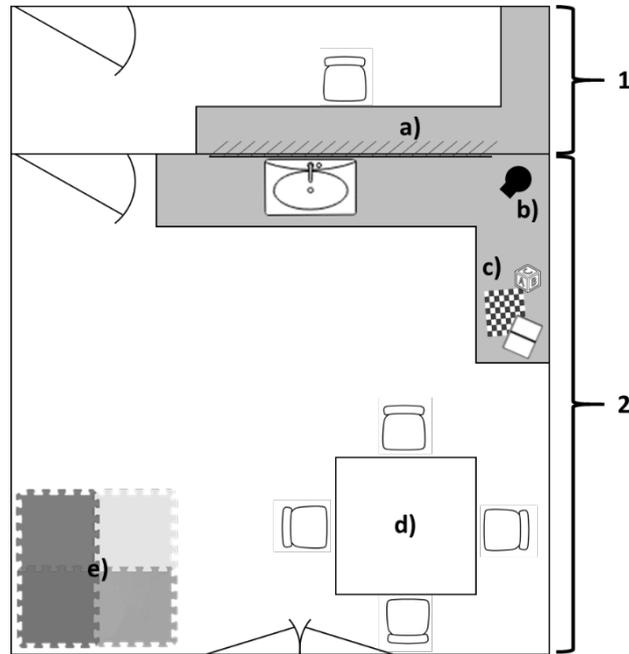
Table captions

Table 1: General characteristics of the children with ASD and the service dog included in the observations.

Tactile sensitivity: hypo = children with ASD with tactile hyposensitivity, hyper = children with ASD with hypersensitivity, neither = children with ASD with no tactile specificity.

Comorbidity: AD = Anxiety Disorder, ADD = Attentional Deficit Disorder, ADHD = Attentional Deficit Hyperactivity Disorder, CN = Congenital Nystagmus, EP = Epilepsy, GDD = Global Developmental Delay, ICD = Involuntary Compulsive Disorder, ID = Intellectual Delay, LD = Learning Delay, LCD = Language and Cognitive Delay, LDD = Language Development Disorder, OD = Oppositional Disorder, TS = Tourette Syndrome.

Table 2: Behavioural repertoire of children with ASD. Definition and description of the behavioural items coded in relation to type of data collection.

Table 3: Behaviours displayed by children with ASD and by the two groups differentiated through HCA during interactions with a service dog. In bold: significant difference within behavioural modalities (Friedman and Wilcoxon tests) and significant correlation of behavioural items with age and CARS score; as well as significant differences between groups on the considered behavioural variables (Mann-Whitney U test). In italics: tendencies for difference between groups on the considered behavioural variable. Level of significance: $p < 0.05$

Tables

Table 1:

Participant Number		Information on children with ASD				Information on service dogs	
	Sex	Age at evaluation (years)	Tactile sensitivity	CARS Score	Comorbidity	Breed of service dog	Age (months) of the service dog
1	M	5.9	hypo	29.5	ADHD - LDD	St-Pierre	18.0
2	M	8.5	neither	23.5	ADHD - ICD	St-Pierre	19.4
3	F	10.4	hyper	31.5	ADHD - AD - OD -LD	Labrador	16.5
4	F	10.0	hypo	27.5	ADHD	St-Pierre	20.8
5	M	8.2	hyper	29	ADHD	Labrador	26.9
6	M	12.2	hyper	28.5	ID	St-Pierre	22.6
7	M	9.0	hypo	26	None	St-Pierre	19.4
8	M	11.4	hyper	30	CN	Labernois	26.5
9	M	5.9	hypo	31.5	ADD	Labernois	19.8
10	M	11.7	hypo	26.5	ID	Labrador	20.7
11	M	3.9	neither	25	ADHD	Labrador	25.6
12	M	9,8	neither	31.5	ADHD	St-Pierre	20.3
13	M	8.0	hyper	22	ADHD - TS - LDD	Labernois	24.4
14	M	13.1	hyper	30.5	ADHD - TS - GDD	Labrador	18.6
15	M	6.0	hyper	29.5	LDD	Labrador	24.5
16	M	3.8	hypo	37.5	LCD	St-Pierre	22.3
17	M	10.9	neither	23	ADD	St-Pierre	22.3
18	M	9.0	neither	35	None	Labrador	20.1
19	F	8.5	hypo	19	EP	St-Pierre	21.3
20	F	4.9	hyper	27	None	Labrador	21.6

Table 2:

Type of coding & Behaviour	Definition	Behaviour modalities
Scan Sampling		
Distance	Distance between child with ASD and (1) service dog and (2) *Primary caregiver*. It was measured between the closest body parts.	• Distance was evaluated in terms of the child's arm length: contact, 0–½, ½-1, 1-1½, >1½ arm.
Gaze orientation	Gaze direction was estimated relying on orientation of eyes and head.	• Gaze could be directed at: service dog, parent (primary and secondary caregiver), games and objects, other.
Care	All caring behaviour of the service dog expressed by child with ASD.	• The following items were considered as care behaviours: hold the leash, give a treat, brush the dog, non-adapted.
Focal Sampling		
Physical contact	All physical contacts between a child with ASD and a service dog were taken into consideration.	• Contact could be either direct or indirect (i.e., with an object) and could be initiated by: child, service dog or parent (either primary or secondary caregiver).
Vocalization	All vocalizations (either words or sounds) produced by a child with ASD addressed to or concerning the service dog were taken into consideration. Both semantic and prosodic information were used.	• Vocalizations could be addressed to either: service dog, parent (either primary or secondary caregiver) or not directed. • Five types of vocalizations were differentiated: service dog's name, command, reflecting attraction to the service dog (VA), reflecting rejection of the service dog (VR), other (i.e., reflecting neither attraction nor rejection of the service dog).
Gesture	All gestures of a child with ASD towards a service dog were taken into consideration.	• Five types of gestures were differentiated: command, reflecting attraction to the service dog (VA), reflecting rejection of the service dog (VR), contact attempt (i.e., child initiated a contact gesture but withdrew his/her hand just before making contact), other (i.e., reflecting neither attraction nor rejection of the service dog).

Table 3:

Categories of behaviours	Modality	Behaviours	Mean	SD	Comparisons within modality	Correlation with age	Correlation with score on CARS	Group1 (Mean ± SD)	Group2 (Mean ± SD)	U	Z	p
Contact with service dog	Total time (duration in s)	Time in contact	249,9	187,1	-	$r_s = 0.60, p = 0.005$	$r_s = -0.11, p > 0.05$	132.7 ± 70.70	467.4 ± 126.06	0,0	**-3.57**	**< 0.001**
	Initiator (duration in s)	Service dog	12.7	22.8	$F = 31.4$ $p < 0.001$	$r_s = 0.37, p > 0.05$	$r_s = 0.38, p > 0.05$	10.4 ± 14.86	17.0 ± 31.15	41.5	-0.28	> 0.05
		Parent	10.2	16.9		$r_s = -0.14, p > 0.05$	$r_s = 0.24, p > 0.05$	8.3 ± 10.59	13.8 ± 25.55	44.0	0.09	> 0.05
		Child	227.0	177.0		$r_s = 0.60, p = 0.005$	$r_s = -0.09, p > 0.05$	114.1 ± 58.32	436.6 ± 116.60	0.0	**-3.57**	**< 0.001**
	Type (duration in s)	Direct contact	190.6	173.9	$Z = 3.17,$ $p = 0.002$	$r_s = 0.68, p = 0.001$	$r_s = 0.04, p > 0.05$	84.9 ± 57.12	386.9 ± 141.89	0.0	**-3.57**	**< 0.001**
		Indirect contact	59.3	43.9		$r_s = 0.03, p > 0.05$	$r_s = -0.45, p = 0.05$	47.8 ± 38.11	80.5 ± 48.91	27.0	-1.43	> 0.05
Vocalization	Type (occurrence)	Attraction	17.3	10.0	$F = 49.6$ $p < 0.001$	$r_s = 0.33, p > 0.05$	$r_s = -0.28, p > 0.05$	16.9 ± 7.26	18.1 ± 11.92	45.0	0.00	> 0.05
		Rejection	3.9	4.7		$r_s = -0.12, p > 0.05$	$r_s = 0.18, p > 0.05$	4.7 ± 4.73	2.5 ± 2.66	32.0	1.04	> 0.05
		Service dog's name	7.6	7.3		$r_s = 0.09, p > 0.05$	$r_s = -0.09, p > 0.05$	9.0 ± 7.37	4.8 ± 3.12	28.5	1.31	> 0.05
		Command	47.6	44.7		$r_s = 0.29, p > 0.05$	$r_s = 0.23, p > 0.05$	54.8 ± 47.76	34.3 ± 10.70	37.0	0.64	> 0.05
		Neutral	28.6	16.5		$r_s = -0.15, p > 0.05$	$r_s = -0.64, p = 0.007$	28.8 ± 16.35	28.2 ± 12.03	44.0	-0.08	> 0.05
	Target (occurrence)	Service dog	82.3	60.6	$Z = 3.36,$ $p = 0.001$	$r_s = 0.33, p > 0.05$	$r_s = 0.09, p > 0.05$	94.1 ± 62.63	60.5 ± 22.15	34.0	0.88	> 0.05
		Parent	22.6	11.4		$r_s = -0.29, p > 0.05$	$r_s = -0.43, p > 0.05$	20.1 ± 9.74	27.3 ± 9.84	25.0	-1.59	> 0.05
Gesture addressed to service dog	Type (occurrence)	Attraction	3.2	3.6	$F = 43.2$ $p < 0.001$	$r_s = 0.40, p > 0.05$	$r_s = -0.31, p > 0.05$	2.1 ± 2.39	5.4 ± 4.53	20.0	**-1.99**	**0.047**
		Rejection	6.1	5.7		$r_s = -0.25, p > 0.05$	$r_s = 0.12, p > 0.05$	6.8 ± 5.32	4.9 ± 6.53	31.0	1.11	> 0.05
		Command	33.1	36.6		$r_s = 0.37, p > 0.05$	$r_s = 0.15, p > 0.05$	39.4 ± 44.16	21.5 ± 10.07	38.0	0.56	> 0.05
		Neutral	3.0	3.8		$r_s = 0.38, p > 0.05$	$r_s = -0.11, p > 0.05$	3.4 ± 4.57	2.1 ± 1.73	44.0	0.08	> 0.05
		Attempt	1.7	1.7		$r_s = 0.29, p > 0.05$	$r_s = 0.40, p > 0.05$	2.1 ± 1.84	0.8 ± 1.11	23.0	*1.77*	*0.077*
Gaze orientation	Target (frequency in %)	Service dog	62.0	19.8	$F = 27.1$ $p < 0.001$	$r_s = 0.77, p < 0.001$	$r_s = 0.01, p > 0.05$	55.1 ± 21.11	74.7 ± 7.58	20.0	**-1.98**	**0.048**
		Parent	8.0	4.8		$r_s = 0.11, p > 0.05$	$r_s = -0.31, p > 0.05$	6.1 ± 4.34	11.4 ± 3.73	17.5	**-2.18**	**0.029**
		Objects and Games	14.8	19.3		$r_s = -0.64, p = 0.002$	$r_s = 0.07, p > 0.05$	21.1 ± 21.00	3.2 ± 7.14	14.0	**2.48**	**0.013**
		Other	15.3	5.8		$r_s = -0.31, p > 0.05$	$r_s = 0.12, p > 0.05$	17.7 ± 5.47	10.7 ± 2.85	8.0	**2.93**	**0.003**
Distance from primary caregiver	Distance in arm-length (frequency in %)	Contact	1.9	3.3	$F = 46.2$ $p < 0.001$	$r_s = -0.19, p > 0.05$	$r_s = 0.06, p > 0.05$	1.1 ± 2.25	3.2 ± 4.79	30.0	-1.25	> 0.05
		0.5	27.9	14.3		$r_s = -0.21, p > 0.05$	$r_s = -0.22, p > 0.05$	27.2 ± 13.84	29.1 ± 16.04	42.0	-0.24	> 0.05
		1	23.9	10.2		$r_s = -0.39, p > 0.05$	$r_s = -0.23, p > 0.05$	24.3 ± 10.87	23.3 ± 9.79	41.0	0.32	> 0.05
		1.5	15.0	6.1		$r_s = 0.49, p = 0.03$	$r_s = -0.10, p > 0.05$	12.9 ± 4.61	18.9 ± 6.84	19.0	**-2.06**	**0.039**
		More	31.3	20.5		$r_s = 0.21, p > 0.05$	$r_s = 0.25, p > 0.05$	34.5 ± 20.74	25.4 ± 20.35	37.5	0.60	> 0.05
Distance from service dog	Distance in arm (frequency %)	Contact	21.3	16.4	$F = 38.4$ $p < 0.001$	$r_s = 0.67, p = 0.002$	$r_s = -0.12, p > 0.05$	11.5 ± 7.22	39.7 ± 12.17	0.0	**-3.57**	**< 0.001**
		0.5	36.1	7.4		$r_s = 0.23, p > 0.05$	$r_s = 0.27, p > 0.05$	37.2 ± 6.47	34.1 ± 9.06	31.0	1.11	> 0.05
		1	18.2	6.8		$r_s = -0.05, p > 0.05$	$r_s = 0.02, p > 0.05$	20.6 ± 6.84	13.6 ± 3.93	17.0	**2.22**	**0.027**
		1.5	9.9	5.0		$r_s = -0.42, p > 0.05$	$r_s = 0.03, p > 0.05$	12.0 ± 4.60	6.0 ± 3.28	13.0	**2.54**	**0.011**
		More	14.5	11.4		$r_s = -0.64, p = 0.002$	$r_s = -0.01, p > 0.05$	18.7 ± 11.72	6.7 ± 5.07	11.0	**2.69**	**0.007**
Care behaviour	Type (frequency in %)	No Care	76.7	13.0	$F = 37.0$ $p < 0.001$	$r_s = -0.60, p = 0.005$	$r_s = -0.06, p > 0.05$	80.3 ± 12.21	70.0 ± 12.19	23.0	1.74	> 0.05
		Hold the leash	6.8	9.3		$r_s = 0.28, p > 0.05$	$r_s = 0.06, p > 0.05$	5.9 ± 9.23	8.5 ± 10.05	40.0	-0.42	> 0.05
		Give a Treat	6.1	6.2		$r_s = 0.46, p = 0.04$	$r_s = 0.23, p > 0.05$	6.1 ± 6.67	6.1 ± 5.60	44.5	-0.04	> 0.05
		Brush the dog	8.2	5.7		$r_s = 0.10, p > 0.05$	$r_s = -0.40, p > 0.05$	6.0 ± 5.07	12.4 ± 4.44	14.0	**-2.46**	**0.014**

Supplemental file 1

Detailed behaviour coding definitions applied for the coding of children with ASD's interactions with a service dog.

Scan Sampling

The following behaviours were collected using the scan sampling technique with a 10-second inter-scan interval. Each behavioural item was coded based on the children with ASD's current activity at sampling time (i.e. every 10 seconds) throughout the observation period.

Distance

Child with ASD's spatial distances were collected at each sampling time. A child with ASD's spatial distances from (1) the *service dog* and from (2) the *primary caregiver* were collected. Distances were evaluated between the child with ASD's body part closest to any body part (i.e. the closest) of the social partner (i.e., the service dog and the primary caregiver). Distances were evaluated using length of the child with ASD's arm. Distances were coded according to the following definition:

- (a) *Contact*: Child with ASD is in physical contact (i.e., either direct (skin to skin; skin to fur) or indirect (contact through an object)).

- (b) *0 – 0.5*: Child is not in physical contact and his/her closest body part is at a distance of less than half his/her arm length from the closest body part of the social partner (i.e. service dog and primary caregiver).

- (c) *0.5 – 1*: Child's closest body part is at a distance ranging between half and 1 his/her arm length from the closest body part of the social partner.

- (d) *1 – 1.5*: Child's closest body part is at a distance ranging between 1 and 1 1/2 his/her arm length from the closest body part of the social partner.

- (e) *>1 ½*: Child's closest body part is at a distance superior to 1 1/2 his/her arm length from the closest body part of the social partner.

Gaze orientation

Child with ASD's gaze orientation was collected at each sampling time. It was estimated based on the orientation of the child with ASD's eyes and head at the sampling time. The target of gaze was recorded in accordance with the following definitions:

- (a*) Service dog*: the child with ASD's gaze and head are oriented towards the service dog.

- (b) parent: the child with ASD's gaze and head are oriented towards the primary or secondary caregiver.

- (c) *Games and objects*: the child with ASD's gaze and head are oriented towards boardgames, toys or objects present in the room.

- (d) *Other*: the child with ASD's gaze and head are not oriented towards any of the targets listed above.

Care

Care behaviour displayed by the child with ASD were collected at each sampling time. Four care behaviours were recorded in accordance with the following definitions:

- (a) *Hold the leash*: the child with ASD is physically holding the service dog's leash in his/her hand.

- (b) *Give a treat*: the child with ASD is holding the treat box in his/her hand and/or is holding a treat in his/her hand to give it to the service dog.

- (c) *Brush the dog*: the child with ASD is holding the brush and/or is brushing the service dog with it.

- (d) *Non-adapted*: the child with ASD does not use any of the devices implied in the care behaviours mentioned above in a standard manner (e.g., brushes the dog with the back of the brush, holds the treat box without retrieving a treat from it, puts the dog's leash around his/her neck, …)

Focal Sampling:

The following behaviours were collected using the focal sampling technique. Thus, the behaviours listed below were collected and coded continuously (i.e., durations and occurrences) throughout the observation period.

Physical contact

Durations of each physical contact between a child with ASD and a service dog were collected throughout the entire free interaction period. Physical contact implies the absence of distance between any part of a child with ASD's body and any part of a service dog's body. Direct and indirect contacts were distinguished based on the presence or absence of an object mediating contact between a child with ASD and a service dog. All contacts were coded using the following definitions to distinguish type of contact:

- (a) *Direct*: any part of a child with ASD's body is directly in physical contact with any part of a service dog's body.

- (b) *Indirect*: contact between any part of a child with ASD's body with any part of a service dog's body is established through an object (e.g., the brush, a toy…).

The initiator of the contact was recorded. The initiator of a physical contact between a child with ASD and a service dog was recorded according to the following definitions:

- (1) *Parent*: The physical contact follows (less than 5s) a suggestion or a directive made by the primary or secondary caregiver, or is performed though parental modelling (i.e., a parent holds a child with ASD's hand to touch or stroke the dog).

- (2) *Dog*: The dog approaches and makes contact with the child with ASD with part of its body.

- (3) *Child*: The child with ASD approaches and makes contact with the service dog with any part of his/her body, without previous parental suggestion or directive from his/her parent.

Vocalizations

Occurrences of all vocalizations produced by a child with ASD towards, concerning or in reaction to a service dog. Vocalizations could be words and sentences pronounced as well as sounds (e.g., laugh, giggle, scream, grunt…). Five types of vocalizations were coded according to the following definitions:

- (a) *Service dog's name*: a child with ASD pronounces the dog's name alone in an isolated sentence (at least 2s from another word).

- (b) *Command*: a child with ASD pronounces a word corresponding to a command the dog might respond to (i.e., sit, stay, come, lay down…).

- (c) *Reflecting attraction*: a child with ASD emits a vocalization reflecting interest or a wish to make contact with the service dog, a positive affect to make contact with it, a positive comment towards it or paraverbal

vocalizations expressing positive affects towards the service dog (e.g., laugh, positive exclamation or excitement, giggles).

- (d) *Reflecting rejection*: a child with ASD emit a vocalization reflecting absence of interest or unwillingness to make contact with a service dog, a negative affect to contact it, a negative comment towards it or paraverbal vocalizations expressing negative affects towards the service dog or the contact with it (e.g., scream, disgust vocalization ["eww"] ...).

- (e) *Other:* a child with ASD emits a vocalization reflecting neither attraction nor rejection of the service dog (e.g., describes the service dog, describes an ongoing action with the service dog, presents an object verbally to the service dog…).

The target of the collected vocalizations was recorded. Targets of vocalizations were coded according to the following definitions:

- (1) Service dog: a child with ASD talks directly to the dog or vocalizes in reaction to one of its actions.

- (2) Parent: a child with ASD talks to the parent directly or vocalizes in reaction to something he/she did or said.

- (3) Not directed: a child with ASD talks or emits a vocalization that is not oriented towards a social target (e.g., comments his/her own action to him/herself, echolalia…).

Gestures

Occurrences of all gestures produced by the child with ASD towards the service dog were considered. Only gestures produced by a child with ASD and directed towards a service dog were considered. Gestures oriented towards parents, non-oriented gestures,

self-centred gestures and stereotypic gestures were not coded. Five types of gestures were coded according to the following definitions:

- (a) *Reflecting attraction*: a child with ASD emits a gesture reflecting interest or a wish to make contact with the service dog or shows a positive affect towards it (e.g., claps his/her hands to congratulate the dog, shakes his/her hand to say hello, gives thumbs up…).

- (b) *Reflecting rejection*: a child with ASD emits a gesture reflecting absence of interest or unwillingness to make contact with the service dog or shows a negative affect towards it (e.g., push the dog, retrieves his/her arm to avoid contact…).

- (c) *Contact attempt*: a child with ASD initiates a contact gesture (i.e. approachs part of his/her body near to the service dog) but withdraws his/hand (or any other part of his/her body) just before making physical contact with the service dog.

- (d) *Other*: a child with ASD emits a gesture reflecting neither attraction nor rejection of the service dog (e.g., points an object to the dog…).