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1 **Visual exploration and observation of real-life interactions between children with ASD**
2 **and service dogs**

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15

16 Autism Spectrum Disorder (ASD) figures among neurodevelopmental disorders, and its
17 symptoms appear mainly during early childhood. It is characterized by a triad of alterations
18 persisting over time and development (DSM-5; APA, 2013): (1) impairment of communication
19 skills, including language deficits, deficit in joint attention and avoidance of reciprocal gaze;
20 (2) difficulties in social interactions, with limited interest and issues to connect with others as
21 well as (3) restricted and/or repetitive behaviours and interests, including verbal and motor
22 stereotypies (APA, 2013; Wing & Gould, 1979).

23 Difficulties concerning social interactions are among the central issues related to ASD.
24 Different behavioural specificities characterize the social interactions of people with ASD such as
25 a particular inter-individual distance adjustment (Asada et al., 2016; Gessaroli et al., 2013),
26 avoidance or aversion of human gaze (Grandin, 1995), emotional synchrony problems (i.e.
27 infrequency or absence of social smiles), echolalia (e.g. repetition of the same word or phrase)
28 (APA, 2013). These issues relative to people with ASD's social interactions also extend to the
29 extraction of information in social context and from social stimuli. When exploring a visual scene
30 including social agents, people with ASD rarely gaze at the social stimuli (i.e. faces; Osterling &
31 Dawson, 1994; Riby & Hancock, 2008, Papagiannopoulou et al., 2014), and they respond poorly
32 to them in social contexts (i.e. to the pronunciation of their first name, Dawson et al., 1998). In
33 addition, other visual attention abnormalities are associated with ASD, such as abnormal eye
34 contact (i.e. weaker, Dawson et al., 2000) and difficulties in facial recognition (Klin et al., 1999).

35 Social interactions difficulties could be partly overcome through different types of
36 treatment or interventions. Indeed, in parallel to drug management, more and more non-
37 pharmacological alternatives have been developed to improve the daily lives of people with
38 ASD, and in particular intervention methods involving animals (Redefer & Goodman, 1989;
39 O'Haire, 2017; Philippe-Peyrouet & Grandgeorge, 2018). It would appear that interactions with
40 animals (i.e., either as a therapy animals in animal assisted intervention, or as pets or service

41 dogs at home) have positive effects on various facets of children with ASD's development:
42 physical (e.g. motor development facilitator; Byström & Persson, 2015), social (e.g. increased
43 social motivation to communicate and prosocial behaviours; Redeker & Goodman, 1989;
44 Carlisle, 2012) and emotional aspects (e.g. comforting, regulating feelings and stress; Byström
45 & Persson, 2015, Viau et al., 2010). Similarly, a decrease of problematic behaviours has been
46 observed (e.g. running away, crises; Redeker & Goodman, 1989; Carlisle, 2012). Integrating an
47 animal into the home of children with ASD (i.e., either a pet or a service dog) has been
48 demonstrated to improve their prosocial skills related to empathy (e.g., *with pets*, offering
49 sharing and comfort, Grandgeorge et al., 2012b). Moreover, in the presence of a therapy dog,
50 children with ASD laugh more often, are in a happier mood, and engage more in conversation
51 with the therapist about the therapy dog (Martin & Farnum, 2002). An animal, whatever its
52 status (i.e. pet, therapy or service animal), may also facilitate a positive reinforcement of
53 children with ASD's social behaviours, and this in turn facilitates communication with others
54 and the development of their social skills (Carlisle, 2012). However, it is important to note that
55 these benefits may vary according to various factors such as the severity of children with ASD's
56 sensory impairment or their parents' attitude (Carlisle, 2014a). Among the various forms of
57 interventions including animals, an increasing use and demand of service dogs for children with
58 ASD emerges (Walther et al., 2017). Service dogs for children with ASD received a specialized
59 training in order to follow and support these children in all aspects of their life, with the aim to
60 increase their daily functioning and well-being (Davis et al., 2004; O'Haire et al., 2015). In fact,
61 the latest INESSS report (2019), summarizing the benefits of dogs for children with ASD,
62 highlights that service dogs bring more benefits (e.g. social skills) than do pet dogs.

63 The benefits of owning a pet seem to be greater if the child bonds with the animal (Melson,
64 1991). Therefore, the benefits for children with ASD stem from the initial attraction to the animal
65 (Carlisle, 2012; Maurer et al., 2011). Numerous children with ASD are attracted to animals

66 (Grandin, 1995; Prothmann, et al, 2009, Maurer et al., 2011; Grandgeorge et al., 2012a, Dollion
67 et al., submitted) and various hypotheses have been proposed to explain this attraction
68 (Prothmann, et al., 2009; Leslie, 1994; Redefer & Goodman, 1989). Among them, authors
69 propose that this attraction may rely on the specificities of the interaction with the animal for
70 children with ASD. Animals' behaviours would be more predictable and less complex to decode
71 than those of human beings, and the interaction with the animal relies on modalities more suited
72 to people with ASD (i.e. favouring tactile versus verbal modality) (Redefer & Goodman, 1989).
73 Leslie (1994) even suggests the distinction between animals, as agents of actions (i.e. communicating
74 their intentions non-verbally via body language) and humans, as agents of attitudes (i.e. using meta-
75 representations). In line with these specificities of interactions with animals and their benefits for
76 children with ASD, some authors suggest that a phenomenon of behaviour generalisation could be
77 at the core of these benefits. Animals act as the first "transitional objects" for children with ASD, and
78 they then extend this initial connection and the behavioural strategies developed during interactions
79 with animals to other human beings (Winnicott, 1986; Martin & Farnum, 2002). Similarly, animals
80 would be a very attractive multisensory stimulus for these children (Martin & Farnum, 2002; Redefer
81 & Goodman, 1989). More recently, studies tend to show that nature of the interactions observed
82 between children with ASD and animals, and particularly visual behaviours, could be one way to
83 explore among the explanatory mechanisms (Grandgeorge et al., 2016, 2017; Valiyamattam et al.,
84 2020).

85 Knowing the issues of people with ASD regarding interactions with human agents,
86 notably concerning attraction to social agents and stimuli and their visual exploration, it seems
87 legitimate to hypothesize that these difficulties may also extend to interspecific interactions.
88 Nevertheless, studies tend to show that these difficulties would be less marked with animals
89 (Maurer et al., 2011; Carlisle, 2014b). Indeed, as stated above, numerous children with ASD
90 are attracted to animals and are not only able to interact with them, but also to establish

91 privileged relationships with them (Maurer et al., 2011; Grandgeorge et al., 2012b). Several
92 studies confirm that animals are attractive visual stimuli to children with ASD, both in 2D (i.e.
93 picture of animals) and in real life (i.e. animal present in the room) (Celani, 2002; Prothmann
94 et al., 2009). Experiments conducted using image presentation (human, animal versus object) show
95 that children with ASD gaze more at animals than at humans and objects (Celani, 2002). Moreover,
96 when given a choice, children with ASD interact preferentially (in terms of duration and
97 occurrence) with an unfamiliar animal (e.g. stroking, initiation of play; Prothmann et al., 2009) than
98 with an unfamiliar toy or an unfamiliar human. This interest in animals translates into various types
99 of interaction and different interaction profiles. In their study in “close to life” conditions,
100 Grandgeorge et al. (2012a, 2014) observe that during the first encounter with an unfamiliar guinea
101 pig, children with ASD could interact according to three interaction profiles: (1) “turned towards
102 humans” profile (the most frequent, with the child directing many glances towards the observer and
103 its parent, with verbal interactions about the animal with its parent), (2) “self-centered” profile (the
104 child manifests motor and verbal stereotypies, showing little or no interest in the animal) and finally
105 (3) “confident” profile (common to neurotypical children in the same situation where the child goes
106 straight to the animal, smiles and touches/kisses the animal) (Grandgeorge et al. , 2012a). More
107 recently, here again, three behavioural profiles of children with ASD interacting with an
108 unknown service dog were distinguished: “proximal and contact with the service dog” (i.e.,
109 children who spend more time in contact with the service dog and initiated contact with it),
110 “distal and command to the service dog” (i.e., children who notably gave commands to the
111 service dog and interacted with it through distal behaviours such as vocalisations, gestures and
112 gazes) , as well as “disinterest for the service dog” (i.e., children who displayed more rejection
113 gestures and vocalisation towards the service dog, and less attraction and neutral behaviors (e.g.
114 vocalisations, gestures) towards it) (Dollion et al., submitted). It would thus seem that the animal
115 represents a source of motivation to interact (visually, vocally), at least for many children with

116 ASD. However, not all children with ASD are attracted by the animal and/or are able to establish
117 a bond with it (Grandgeorge et al. 2012b). For example, Grandgeorge et al. (2012a) report that a
118 third of the observed children did not exhibit any prosocial behaviours, either towards humans or
119 animals, and some maintained a distance and remained indifferent to the presence of the unknown
120 animal (i.e. guinea pig). Similarly, some children with ASD in the presence of an unknown service
121 dog remained at distance and rejected it (Dollion et al., submitted). In addition, some children with
122 ASD are attracted more to some animals than to others. Some parents describe their children with
123 ASD as being afraid of dogs, but that other pets are more tolerated, such as cats or rabbits (Carlisle,
124 2012, 2014a; Hart et al, 2018).

125 Visual exploration of conspecifics, especially human faces is a key element in social
126 interactions used by neurotypical people (Racca et al., 2012). As previously highlighted, visual
127 exploration of social stimuli also entangles specificities in ASD. Alterations in sensory and
128 perceptual processes can lead to alterations in the establishment of representations and in interactions
129 with their environment. Indeed, malfunction in the first perceptual processes may lead to alterations
130 in the extraction of information, and this may result in a general misrepresentation of the object. Such
131 alterations are often observed in people with ASD, including hypo-/hyper-sensitivity and perceptual
132 disorder, such as defective sorting of information flow (e.g. auditory, visual, tactile). This could
133 contribute to their difficulties in interpreting social situations and may explain the presence of
134 context-inappropriate behavioural responses (e.g. Gepner & Feron, 2009). In relation to these
135 alterations, the presence of an atypical visual exploration pattern in people with ASD (Klin et al.,
136 2002; Riby & Hancock, 2008) could lead to poor information extraction, and therefore poor decision
137 making, and explain certain behaviours specific to ASD (Mottron & Burack, 2012). For example,
138 avoidance of human faces and of eye-contact during social interactions deprives perception of the
139 orientation of other people's attention and thus disrupts joint attention. This type of issue (i.e.
140 establishing and maintaining joint attention) lead people with ASD to have difficulties sharing

141 experiences (Bogdashina & Casanova, 2016), or poor synchronisation of emotions with others (i.e.
142 understanding the emotional state of the other and therefore adapting/regulating their behaviour
143 accordingly through the emotional contagion process (Prochazkova, 2017)). Therefore, atypical
144 information extraction from social stimuli and agents could be an explanatory track to people with
145 ASD's interaction difficulties (Grandgeorge et al., 2016, 2017, Papagiannopoulou et al., 2014).
146 Given these elements, it seems interesting to look at the visual strategies of the children with ASD
147 with the animal, in order to know if alterations observed with human also extend to animals.

148 Among the visual cues that can be extracted during an interaction and that may
149 significantly contribute to it, gaze is a non-verbal vector by which an individual communicates
150 to his or her partner his or her state of attention and level of readiness to interact (Burgoon et
151 al., 2016). Children with ASD do not exhibit a "triangular" (eyes and mouth) exploration pattern
152 when gazing at human faces (Amestoy, 2013; Valiyamattam et al., 2020). They pay less
153 attention to the eye area, and pay more attention to the lower hemi-facial area (Jones et al.,
154 2008; Klin et al, 2002; Spezio et al., 2007). Yet, paying attention to the eye area allows an
155 individual to capture a great deal of information and contributes to the establishment of
156 interactions with others (Klin et al., 2002). Moreover, some authors suggest that staring at the
157 eyes of a face may cause an increased emotional response for people with ASD (e.g. « his mind
158 went blank and his thoughts stopped; it was like a twilight state » Grandin, 1995). Yet, although
159 they explore significantly less of an animal's eye area than do neurotypical children, it seems that
160 the so-called "triangular" exploration is preserved in children with ASD when exploring animal faces
161 (cats, dogs, horses) (Amestoy, 2013; Grandgeorge et al., 2016). Furthermore, a recent study
162 confirmed the positive attentional bias towards animal images and showed that children with ASD
163 pay significantly more visual attention to the face and eye area of frontal animal images compared
164 to averted animal images (Valiyamattam et al., 2020). In addition, people with ASD's recognition of
165 human facial emotions is better when combined with an animal filter (e.g. human face with the

166 contours of a gorilla or lion; Cross et al., 2019). Thus, it appears that while alterations of the
167 extraction of visual information from human social agents by children with ASD are observed, the
168 same do not apply with animals.

169 While the benefits from the interaction with animals for people with ASD are well
170 documented, the source of these benefits and their underlying mechanisms are still a matter of
171 debate. All together, studies highlight that among the possible explanatory leads, one would be
172 that the pattern of visual exploration used by children with ASD with animals differs from the
173 one they use with human agents (Grandgeorge et al., 2016; Valiyamattam et al., 2020). Could
174 this difference in information gathering be at the basis of the difference in interest and
175 interaction profiles that can be observed in children with ASD when interacting with an animal
176 (Grandgeorge et al., 2012a, 2014; Dollion et al., submitted)? Indeed, one could argue that the
177 way children with ASD decode information about animals and interact with them is a direct
178 reflection of their current representation of animals and therefore of their interest in them. In
179 this context, the aim of our study was to explore the links between the visual attention of
180 children with ASD towards animals, here dogs by the end of their training to become service
181 dogs¹, and the kind of interactions they developed with them. Based on the current literature
182 (Grandgeorge et al., 2011, 2012a, 2011; Martin & Farnum, 2002; Prothmann et al., 2009;
183 Dollion et al., submitted), we may hypothesize that the dog would be an attractive visual target
184 for children with ASD, resulting in an increased attention towards it. Since not all children with
185 ASD present the same level of interest, we expect that observations of their behaviour would
186 reveal different profiles of interaction with the dog, as previously observed (Dollion et al.,
187 submitted). Our research was based on an ethological approach involving direct observations
188 and, on an exploratory basis, eye-tracking in a real context of interactions. In the first study,
189 behaviours displayed by children with ASD while interacting for the first time with a future
190 service dog in a standardized situation were evaluated. In the second study, conducted with an

191 exploratory approach, the same design was applied with the addition of a wearable eye-tracking
192 system (i.e. eye-tracking glasses), in order to provide a finer measure of the children with ASD's
193 visual attention while interacting with the future service dog.

194

195 **Study 1**

196 **Materials and methods**

197 *Subjects*

198 Videos were collected from Summer 2011 to Summer 2014.

199 **Children with ASD.** Recordings were extracted from the Mira Foundation's database, which
200 include videos of the standard evaluation performed by the foundation to establish the
201 admissibility of children in their service dog program. The inclusion criteria for the present
202 study were established as followed: child must have a diagnosis of ASD delivered by a clinician
203 (i.e., pediatrician, pedo-psychiatrist, neuropsychologist), have a full recording of his/her first
204 evaluation at the Mira Foundation and must not have previously been the recipient of a service
205 dog, parents must have provided a written to use their child with ASD's recording for the
206 present study. For ethical reasons, all children included in the present study had been judged as
207 being eligible for the Mira Foundation's service dog program. Sixteen children with ASD were
208 included in the first study (mean age \pm SE: 8.5 ± 0.7 years old; 3.9-13.1 years old; 14 boys and 2
209 girls). Most of them (87.5%) had co-morbidities (e.g. Attention Deficit Hyperactivity Disorder
210 or ADHD, intellectual defiance, Tourette syndrome). Each child included in the project had
211 been evaluated using the Childhood Autism Rating Scale (C.A.R.S; Schopler, et al., 1988) by
212 a professional (i.e. psychologist, psychoeducator, educational psychologist) to establish the
213 severity level of their ASD. All were rated with a mild to moderate severity of ASD (C.A.R.S;
214 mean score of 27.7 ± 1.0). All children with ASD were fully verbal, except for one who was
215 partially verbal.

216 **Dogs participants.** Fifteen trained dogs were used. All originated from the Mira Foundation's
217 husbandry. They were 10 females and 5 males, including 5 Labradors, 3 Labernois and 5 Saint-
218 Pierre (mean age: 22.0 ± 0.7 months at the time of the observations). All received the same
219 training protocol and were at the end of their training to become service dog for children with
220 ASD (i.e. about 2.5 months at least). As previously mentioned in footnote, dogs used in the
221 present study were not service dogs per se, but were dogs by the end of their training to become
222 service dogs. They will however be referred as service dogs in the rest of the manuscript for the
223 sake of clarity. Each child with ASD met a different service dog, except two children with ASD
224 who were observed within the same week and thus same service dog was present during
225 observations.

226 *Experimental Design*

227 *Material*

228 All observations were performed at the Mira Foundation (Quebec) in a room dedicated to
229 observation and assessment of children with ASD (table, board games and toys, water point,
230 carpet, window). This room was equipped with a wide-angle camera and an adjacent airlock
231 with a one-way mirror, allowing non-participant observation.

232 *Procedure*

233 The observations resorted to the usual procedure applied by the Mira Foundation and was
234 conducted by a professional (i.e. psychologist, psychoeducator, educational psychologist) from
235 the Mira foundation. In order to assess the eligibility of families to receive a service dog, a
236 standard evaluation procedure was used in the presence of one or two parents. Brothers and
237 sisters could be present as well (i.e., one sibling: N=7; two siblings: N=1). Evaluations were
238 always performed as followed:

264 Phases 3 and 5 (approximately 10 minutes respectively) were extracted from video-recordings
265 and analysed using The Observer XT software (version 11.0, Noldus, Netherlands). All child
266 with ASD's behaviours towards the service dog and his/her parent's vocalisations concerning
267 him/her and the service dog were considered (Table 1).

268 Ethological methods of behavioural coding were applied to analyse the videos (Altmann, 1974):
269 (1) scan sampling (i.e. collecting behavioural data from an individual's current activity at
270 preselected moments in times, thus allowing an estimation of the child's time budget spent on
271 the different activities) with an inter-scan interval of 5 seconds (i.e. 241 scans per child); (2)
272 focal sampling (i.e. recording continuously an individual's behaviours of interest for a
273 predefined sampling period, thus allowing an estimation of occurrences and durations of
274 behavioural states).

275 Scan sampling was used to sample spatial distances between the child with ASD and the service
276 dog, spatial distances between the child with ASD and his/her closest parent (both measured in
277 terms of the child's arm), as well as the child with ASD's care behaviours towards the service
278 dog and his/her gaze orientation. All contacts between the child with ASD and the service dog,
279 his/her gestures directed towards it and the child with ASD's and his/her parent's vocalisations
280 were collected by focal sampling. We considered as command vocalisations and gestures, every
281 vocalisation and gesture to which the service dog had been trained (i.e. sit, stay, lie down,
282 come), but also vocalisations and gestures from the child with ASD aiming to trigger an action
283 from the service dog (e.g. "give paw"). The selection of behavioural items collected in the
284 present study was based on a previous study (Dollion et al., submitted). The behaviors collected
285 in the present study are thus similar to this previous study, but with some additions (i.e. parents'
286 conversation, active/passive contact with the service dog, gaze orientation towards the dog
287 accessories). As parents were present during the interaction, we were interested in the role they

288 might have on their child's behaviours with the service dog. Therefore, vocal interventions of
289 parents relative to their child's activity with the service dog were recorded by focal sampling.
290 A blind spot was present (i.e. a part of the room not covered by the camera) and limited the
291 visibility and access to the interaction between the child with ASD and the service dog, and
292 thus limited its behavioural coding. Only moments when the child with ASD was visible were
293 coded. Every video segment where part or all of the child with ASD's body was in the blind
294 spot was considered as not codable. The average percentage of codable video time per
295 individual was 88% in this study. Similarly, when the direction of a child's gaze could not be
296 decided between two possible targets, it was coded as unknown.

297 All videos were coded by the same observer (MT). Inter-observer reliability was calculated
298 using a Cohen Kappa test. A second observer (ND) double-coded all behavioural items for
299 18.75% of the videos. Inter-raters reliability was considered excellent (mean Kappa index
300 across all behaviours of 0.81).

301 *Insert Table 1 and caption here*

302 *Statistical analyses*

303 Analyses were performed using R.3.6. software© with an accepted p-level at 0.05. Since data
304 were not normally distributed, non-parametric statistics were used (Siegel & Castellan, 1988).

305 In order to accurately homogenize the observed data, the codable times and occurrences were
306 reportioned over 20 minutes for all individuals (minimum/maximum codable duration: for
307 phase 3 between 4.4 and 9.5 minutes and for phase 5 between 4.9 and 8.6 minutes).

308 In order to explore the general behavioural pattern during interaction, Friedman tests followed
309 by Wilcoxon signed rank tests were applied to determine if some were more expressed than
310 others. A Principal Component Analysis (PCA) was performed. A varimax rotation was applied
311 to the PCA. Scores on factors from the PCA were extracted. Then a Hierarchical Ascending
312 Classification (HAC) based on Ward distances was performed to determine if groups differed

313 on the extracted factors. Differences between groups were tested on scores on factors from the
314 PCA using a Kruskal-Wallis test, followed by a Dunn test with a Bonferonni correction as a
315 post-hoc test. Spearman correlations were performed on age and PCA factors. Partial
316 correlation tests (Spearman's method) were used to test the relationship between gaze and
317 interaction with the service dog (i.e., factors from the PCA), while controlling for the impact of
318 the child with ASD's age.

319 **Results**

320 *Interactions of children with ASD with a service dog*

321 Approximately a quarter of the time, children with ASD were in physical contact with the
322 service dog, and this contact was mostly initiated by the children (compared to the service dog
323 $z=3.31$, $p<0.001$; and the parents, $z=3.52$, $p<0.001$; Table 2). They were also initiated more
324 frequently by the dog than by the parents ($z=2.17$, $p<0.05$). Most physical contacts consisted in
325 active stroking (i.e., contact with movement) rather than in passive stroking (i.e., contact
326 without movement) ($z=2.84$, $p<0.01$).

327 This physical appeal for a service dog was measured also through inter-individual distances.
328 Indeed, children with ASD were in physical contact with the service dog more frequently than
329 with their parents ($z=3.05$, $p<0.01$; Table 2). Conversely, they were more often further away
330 (i.e. distance more than 1.5 arm) from their parents than from the service dog during interactions
331 ($z=2.95$, $p<0.01$). No significant differences between the other child-to-parent *versus* child-to-
332 dog distances could be evidenced ($0.88 \leq z \leq 1.22$, $p>0.05$). Children with ASD were more
333 frequently at a distance from the parents (contact to 0.5 arm *versus* 1 arm and more: $z=3.05$,
334 $p<0.01$), while no preferred distance from the service dog was detected (contact to 0.5 arm
335 *versus* 1 arm and more; $z=0.21$, $p>0.05$).

336 Children with ASD spoke (e.g. “come here”, “good dog”, “[dog's name] sit”) and vocalized
337 (e.g., laughs, giggles, exclamations) more to the service dog compared to their parent(s)

338 ($z=3.36$, $p<0.001$) and to the “other” item ($z=3.52$, $p<0.001$). Children with ASD also vocalised
 339 more towards their parents than towards the “other” item ($z=3.52$, $p<0.001$). The type of
 340 vocalisations mostly used were commands (compared to other vocalisations $2.38 \leq z \leq 3.52$, all
 341 $p<0.001$, except neutral $z=0.41$, $p>0.05$). The vocalisations directed to the service dog were
 342 mainly neutral (compared to attraction, $z=2.59$, $p<0.01$; and rejection, $z=3.52$, $p<0.001$), while
 343 rejection vocalisations were the least expressed ($3.21 \leq z \leq 3.52$, all $p<0.001$). Gestures towards
 344 the service dog were mostly command gestures ($3.36 \leq z \leq 3.52$, $p<0.001$), while there were as
 345 many gestures of rejection as gestures of attraction ($z=0.31$, $p>0.05$). Rejection, inadequate and
 346 attempt gestures were displayed the least ($2.44 \leq z \leq 3.52$, all $p<0.05$).

347 *Insert Table 2 and caption here*

348 Parents' vocalisations aimed mainly at encouraging their child with ASD's activity with the
 349 service dog (compared to rectifying, $z=3.10$, $p<0.01$, and moderating, $z=3.52$, $p<0.001$; Table
 350 2). Moreover, parents rectified more than they moderated their child's activity ($z=3.01$, $p<0.01$).
 351 The service dog was the preferred target of children with ASD's gaze during the interactions
 352 ($2.90 \leq z \leq 3.52$, $p<0.01$). They gazed significantly less at service dog's accessories than at "other"
 353 item ($z=3.47$, $p<0.001$) or their parents ($z=2.53$, $p=0.01$).

354 The children with ASD spent a fifth of the observation time displaying caring behaviours with
 355 the service dog. No significant differences were detected between the care behaviours
 356 considered, except that they gave water less frequently than they gave a kibble, brushed the
 357 service dog or hold its leash ($1.93 \leq z \leq 2.43$, all $p \leq 0.05$). No inappropriate care or gestures
 358 towards the service dog were observed, excepted for one child who pressed his foot
 359 intentionally on the service dog's leg.

360 *Profiles of children with ASD's interactions with service dogs and their visual attention*

361 Even though overall behavioural trends were consistent, three factors of the PCA explained
 362 51.2% of the variance in our dataset (Table 3). After extracting PCA scores from the

363 behavioural variables on the three factors, it was possible to differentiate three interaction
364 strategies.

365 *Insert Table 3 and caption here*

366 The first factor (F1) explained 19.7% of the variance. It was positively loaded by contact with
367 the service dog (i.e. initiated by the child with ASD, brushing, occurrences of contact with the
368 service dog), gaze towards the parent and the service dog, neutral vocalisations about and
369 addressed to the service dog and vocalisations directed to the parent; while it was negatively
370 loaded by greater distance (i.e. distance of more than 1.5 arm length) from the service dog, gaze
371 orientation towards board games and “other”. Thus, the higher the score on this factor, the more
372 children with ASD were notably in physical contact with the service dog and initiated contact
373 with it, the more they talked to the service dog and their parent, and gazed at them, and the less
374 they were far from the service dog. Given these elements, this factor was thus labelled
375 “**proximal interaction and visual attention**” (PIVA).

376 The second factor (F2) was representative of “distal interaction” with the service dog. It carried
377 the main vocalisations (i.e. commands, service dog's name) and gestures (i.e. command,
378 attraction, other) directed towards the service dog by the child with ASD, as well as offering a
379 kibble and greater distance from the parent. Thus, the higher the score on this factor, the more
380 children with ASD talked and addressed gestures to the service dog. Given these elements, this
381 factor was labelled “**distal interaction**” (DI) with the service dog.

382 The third factor (F3) was characterized by vocal supervision of the child with ASD-service dog
383 interactions by the parent (i.e. encourages, temper, rectify) as well as by the child with ASD's
384 contact with the service dog initiated by the parent, the child with ASD-parent contacts and
385 being close to the service dog (within 0.5 arm length). Higher scores on this factor were thus
386 associated with more parental vocal supervision of the interaction between the child with ASD

387 and the service dog, and more initiation of contact between the child and the service dog by the
388 parent. Given these elements, this factor was labelled “**parental guidance**” (PG).
389 Age of the children with ASD was correlated positively with the PIVA factor ($r=0.65$, $p<0.01$).
390 However, their age was not correlated with the other two factors (DI factor (F2): $r=0.15$,
391 $p>0.05$; PG factor (F3): $r=0.06$, $p>0.05$).
392 No significant correlations were observed with the severity of ASD assessed by the CARS (r
393 between $[-0.11; 0.36]$, all $p>0.05$). Thus, children with ASD's age was included as a
394 confounding factor when testing correlations between gaze and interaction profiles. The more
395 children with ASD looked at their parent, the more they interacted proximally (i.e. PIVA factor)
396 with the service dog ($r=0.53$, $p<0.05$). However, they gazed less at their parent when they were
397 more subjected to parental vocal guidance while interacting with the service dog (i.e., PG factor;
398 $r=-0.62$, $p<0.05$). Furthermore, the more the children with ASD interacted proximally (i.e.
399 PIVA factor) with the service dog, the less they gazed at board games ($r=-0.65$, $p<0.01$). The
400 other correlations between factors (i.e., DI and PG factors) and gaze orientations were not
401 significant (all tests, r between $[0.02; 0.47]$, $p>0.075$). It thus appears that gazing at their parents
402 during the interaction with the service dog was associated with children with ASD interacting
403 more proximally with the service dog (i.e., more time in contact with the service dog and more
404 initiation of contacts) and receiving less parental supervision during interaction (i.e., less
405 rectification, encouragement and temperance); while gazing less at board games was associated
406 with more proximal interaction with the service dog.

407 *Interaction profiles*

408 For clarity, only statistically significant effects are reported below. As some behaviours
409 appeared to be related, we aimed at establishing a more global view of these profiles of children
410 with ASD. Three behavioural profiles emerged from the cluster analysis and are described

411 below (Figure 2; Kruskal Wallis Test – F1: $ddl=2$, $N=16$, $X^2= 9.30$, $p<0.01$; F2: $X^2= 9.58$,
412 $p<0.01$; F3: $X^2= 6.02$, $p<0.05$).

413 *Insert figure 2 and caption here*

414 Thus, on the PIVA factor (F1), Group 1 ($N=4$) differed from Group 2 ($N=9$) ($p<0.01$) (Figure
415 2). Group 1 was characterized by more proximal interactions than Group 2. Group 1
416 corresponds to a child's profile that can be labelled “**tactile and visual contact with service**
417 **dog**”.

418 The DI factor (F2) separated the “tactile and visual contact with service dog” children from the
419 Group 3 children ($p<0.01$). Group 3 children ($N=3$) mostly interacted distally with the service
420 dog. So, Group 3 corresponds to a child's profile that can be labelled “**vocal contact with the**
421 **service dog**”.

422 The “tactile and visual contact with service dog” children and Group 2 also differed on the PG
423 factor (F3) ($p<0.05$). The “tactile and visual contact with service dog” children were less
424 subjected to parental guidance during interactions than Group 2. Thus, the profile corresponding
425 to Group 2 was labelled “**subjected to parental supervision**”.

426 Gaze orientation differed between profiles by time children with ASD spent looking at their
427 parents (Kruskal Wallis test: $ddl=2$, $N=16$ for all tests, Cluster - Parent: $p<0.05$; other variable
428 $p>0.05$, Figure 3). Indeed, children with the “tactile and visual contact with service dog” profile
429 gazed significantly more frequently at their parents than did children with ASD “subjected to
430 parental supervision” ($p<0.05$). Although no significant differences were found between
431 profiles for the "board games" variable ($p>0.05$), two-by-two comparisons showed significant
432 differences between profiles as children with ASD “subjected to parental supervision” looked
433 more at board games than did children with ASD of the “tactile and visual contact with service
434 dog” group ($p<0.05$).

435 *Insert figure 3 and caption here*

436

437

Study 2

438

Materials and methods

439

Subjects

440 Videos were collected from January to March, 2020.

441 **Children with ASD.** Inclusion criteria were the same as for Study 1 with in addition three

442 criteria linked to eye tracking usage: children had to be between 6 and 15 years old, not have

443 any epileptic disorder and not wear glasses with a strong correction (i.e., glasses that the child

444 may not be retrieved without discomfort feeling or clear vision difficulties [blurry vision, issues

445 with details within a few meters, and so on]). Nine children corresponding to these inclusion

446 criteria and evaluated at the Mira Foundation were invited to participate. Two children with

447 ASD declined the offer, and one removed the eye-tracking glasses during the experiment. In

448 all, 6 children with ASD participated in the present study (mean \pm SE: 9.3 \pm 1.1 years old; range:

449 6.4 and 14.0 years old; 3 boys and 3 girls). All were diagnosed with ASD and were evaluated

450 by a professional from the Mira Foundation (i.e. evaluator). All were evaluated with mild to

451 moderate severity of ASD (C.A.R.S. mean score of 31.2 \pm 1.8). Only one child had co-

452 morbidities (i.e. ADHD and Anxiety disorder not otherwise specified [AnxNos]). All children

453 with ASD were fully verbal.

454 **Dogs participants.** Four trained dogs were recruited. They originated from the Mira

455 Foundation's husbandry. All were females, including 2 Labradors, 1 Labernois and 1 Saint-

456 Pierre (mean age: 25.3 \pm 1.0 months old at the time of the observations. They had the same

457 training characteristics as in Study 1.

458

Experimental Design

459 *Material*

460 This study was conducted at the Mira Foundation, in the same room as for Study 1 (see section
461 2.1). In this study, the observation room was equipped with two wide-angle cameras (Nest Cam,
462 1920x1080p, 30 images/sec) placed in opposite corners of room to cover the entire room. The
463 conditions and the layout of the room were standardized: same games and placement of objects,
464 shutters systematically closed with the lights on. Eye movements were collected using eye-
465 tracking glasses (Tobii Pro Glasses 2) with a sampling at 60 Hz. Data acquisition and recording
466 were performed with the dedicated software: Tobii Pro Glasses Controller (version
467 1.114.20033).

468 *Procedure*

469 The procedure was identical to the evaluation procedure described in Study 1, except for phases
470 2 and 4, during which the children with ASD had to wear the eye-tracking glasses (Figure 1).
471 All children with ASD had the opportunity to test the glasses before the start of the 5 phases
472 evaluation, to ensure their acceptance to participate (i.e. no discomfort, size of glasses was
473 adjusted as needed).

- 474 ▪ **Phase 2: Presentation of service dog.** The evaluator enters the room, invites the child
475 with ASD to sit on a chair, installs the eye-tracking glasses and performs a one-point
476 calibration. The evaluator brings the service dog into the room and presents the service
477 dog (i.e. name, sex, age, breed, long or short coat, colour, temperament). Then, the
478 evaluator asks the child with ASD two questions concerning the service dog: "How do
479 you like it? Have you ever seen such a big dog?" (mean duration \pm SE = 45.5 \pm 4.9 seconds).
480 Finally, she/he approaches the child with ASD with the service dog and invites the child
481 with ASD to pet it (average duration \pm SE = 13.8 \pm 2.6 seconds of approach and potential
482 contact). Following this, the glasses are removed.
- 483 ▪ **Phase 4: Presentation of objects and commands.** The evaluator enters the room, places
484 the child with ASD on the chair, installs the glasses and performs the calibration. The

485 evaluator brings accessories for the service dog (i.e. a bowl of water, kibbles and a brush,
486 all presented on a stool placed on a predefined mark on the floor), presents the different
487 accessories and the commands to which the service dog is trained to respond (i.e. lie down,
488 sit, stay, come; average duration \pm SE = 98.7 ± 14.5 seconds). Then, the evaluator invites
489 the child with ASD to approach the service dog and give it a kibble (mean duration \pm SE
490 = 13.3 ± 1.3 seconds of approach and potential contact).

491 One or two parents could be present during phases 1 (i.e. habituation phase), 3 (i.e. first free
492 interaction phase) and 5 (i.e. second free interaction phase), as well as brothers and sisters (i.e.,
493 one sibling: N=2).

494 During phases 2 and 4, with the eye-tracking glasses, siblings were asked to wait outside the
495 room and only one of the parents had to stay.

496 The procedure was standardized to optimize the acquisition of valid oculometric data (phases
497 2 and 4). The evaluator's speech was predefined using a script and the position of all individuals
498 within the room was set. The evaluator was placed behind a defined mark on the floor (2.15
499 meters from the child with ASD), the service dog was laying down next to him/her, the parent
500 was asked to sit on a chair specifically placed (i.e. away from the child with ASD, 3 meters to
501 their side) and the child with ASD had to sit on a dedicated chair. In addition, a predefined ideal
502 time for each phase had to be respected as much as possible by the evaluators (i.e. 1 minute 30
503 for phase 2 and 2 minutes 30 for phase 4). The child with ASD was asked not to remove the
504 glasses during the experiment. Furthermore, while the child with ASD was wearing the eye-
505 tracking glasses (i.e. phase 2 and 4) the parent was instructed to remain still and silent. The
506 parent could however answer if the child with ASD questioned him/her directly. Parents were
507 free to interact with their child with ASD during the rest of the evaluation (phases 1, 3 and 5).
508 On the same periods (phase 1, 3 and 5) siblings were free to interact with the child with ASD,
509 as well as with the service dog and their parent.

510 *Data collection and analyses*

511 All sessions of evaluation were video recorded for subsequent analysis.

512 *Data analyses*

513 Behavioural measures were the same as in Study 1.

514 For Eye-Tracking measurements: six Areas Of Interest (AOI) were defined for **Phase 2**
515 **(presentation of service dog)**: the whole service dog, the service dog's head, the evaluator's
516 head, the parent's head, the board games, and the rest of the visual scene, named "other" (i.e.
517 any fixations or saccades recorded elsewhere outside the AOIs defined above).

518 The same six AOIs were used for **Phase 4 (presentation of objects and commands)** with, in
519 addition, a seventh AOI: "service dog's accessories" (including brush, water bowl and kibble
520 box). Each AOI was defined to encompass the entire element of interest (e.g. for the service
521 dog AOI, it included the whole service dog from tip of tail to muzzle, and from top of head to
522 tip of legs).

523 Considering the inter- and intra-individual variability of the actors in the visual scene, the
524 differences in distance between child and service dog as well as the service dog's and the child's
525 head movements during the observation, an additional space has been tolerated and applied
526 around the target item of each AOI. A tolerance of half a service dog's leg for the service dog's
527 body and service dog's head AOIs was applied, and half a hand for the evaluator's head, the
528 parent's head and the objects AOIs.

529 Eye-tracking data were analysed using "Tobii Pro Lab" software Version 1.102.15986 (x64).

530 Extraction of oculometric data was performed using an "I-VT attention filter" (i.e. I-VT:
531 Velocity-Threshold Identification) with a velocity threshold set at 100 degrees/second. For both
532 phases, the starting point of eye-tracking extraction was set when the evaluator began his/her
533 first introductory word (i.e. "I present you..."). The approach phase began when he/she put
534 his/her foot on the other side of the mark on the ground, and ended when the evaluator began

535 her/his first word to announce the end of the experiment ("we are going to take off the glasses").
536 For each AOI, the number of fixations and the total duration of fixation within the AOI were
537 extracted.

538 *Statistical analyses*

539 Since data were not normally distributed, we used non-parametric statistics (Siegel & Castellan,
540 1988). In order to homogenize the extracted data accurately: (1) codable times and occurrences
541 were reportioned over 20 minutes for all individuals (minimum/maximum codable duration
542 for phase 3 were 8.7 and 11 minutes and for phase 5 between were 9.6 and 13.2 minutes); (2)
543 durations of phases 2 and 4 were reportioned to their respective ideal times as defined in the
544 initial evaluators' script (i.e. 1 minute 30 for phase 2 and 2 minutes 30 for phase 4). The eye-
545 tracking data collected (target, occurrence and duration of gaze) were then related to the
546 behavioural traits adopted by the children with ASD with the service dog. Spearman
547 correlations were performed: (1) between the different AOI variables, and (2) between AOI
548 variables and behavioural variables. Mann-Whitney tests were conducted between the AOI
549 variables. All possible comparisons have been made between the AOIs, except for the
550 comparison between the service dog AOI and the service dog head AOI, since these AOI were
551 in fact non-exclusive (i.e. the service dog AOI included the service dog head AOI).

552 **Results**

553 *Characterisation of the visual exploratory pattern based on oculometric analysis*

554 For clarity, only statistically significant effects are reported below. Children with ASD spent
555 more time gazing at the service dog (mean percentage fixation duration: $44.4 \pm 3.2\%$), the service
556 dog's head ($31.4 \pm 2.5\%$) and the rest of the scene AOIs ($31.3 \pm 4.5\%$) than at the board games
557 ($0.1 \pm 0.05\%$; all $z \geq 2.20$, all $p < 0.05$), the service dog's accessories ($7.4 \pm 1.5\%$; all $z \geq 2.20$, all
558 $p < 0.05$) and the evaluator's head ($16.0 \pm 3.5\%$; all $z \geq 2.20$, all $p < 0.05$, except for the rest of the
559 visual scene : $z = 1.78$, $p = 0.07$) (Figure 4a). The evaluator's head and the service dog's

560 accessories were gazed at significantly more than the parent's head and the board games (mean
561 number of fixations: respectively 51.5 ± 7.6 and 43.9 ± 8.2 versus 2.1 ± 1.0 and 0.66 ± 0.4) (for all
562 comparisons: $z \geq 2.02$, $p < 0.05$). Furthermore, children with ASD spent more time gazing at the
563 service dog's head than at the rest of its body (mean percentage fixation duration: $31.4 \pm 2.5\%$
564 of the time, $z = 2.20$, $p < 0.05$).

565 Children with ASD also performed fixations on the service dog more frequently than on all the
566 other AOIs considered (mean number of fixations: 282.9 ± 29.7 vs X between 0.66 ± 0.43 and
567 118.6 ± 22.2 for all other AOIs) (for all comparisons: $z \geq 2.20$, $p < 0.05$; Figure 4b). Similarly,
568 fixations on the service dog's head and on the rest of visual scene were significantly more
569 frequent than on the other AOIs (respectively, 110.6 ± 16.2 and 118.6 ± 22.3 versus X between
570 0.66 ± 0.43 and 51.5 ± 7.6 for all other AOIs) (all comparisons: $z \geq 1.99$, $p < 0.05$). The parent's
571 head and the board games were the least explored (respectively, 0.66 ± 0.44 and 2.09 ± 1.03 , all
572 $z \geq 2.20$, $p < 0.05$). Finally, the number of fixations on the dog's body was higher than on its head
573 ($z = 1.99$, $p < 0.05$).

574 *Insert figure 4 and caption here*

575 *Visual exploration patterns and behavioural variables adopted by children with ASD*
576 *during interactions with the service dog*

577 Correlation analyses were performed between the AOI variables to investigate associations of
578 visual exploration of the different targets. No significant correlations were found either for total
579 fixation time or for number of fixations (total fixation time: r between $[-0.068; -0.83]$, $p > 0.058$;
580 number of fixations: r between $[-0.1; 0.83]$, $p > 0.058$).

581 Correlation analyses were performed between all AOI variables (i.e. total durations of fixation
582 and number of fixations) with all behavioural variables collected for the six children with ASD
583 (cf. Table 1). The selection of behavioural variables included in this analysis was based on

584 results of study 1 (i.e. behavioural variables significantly supporting PCA factors and all gaze
585 orientations).

586 Analyses on animate/social targets (i.e. parent's head; evaluator's head, service dog and service
587 dog's head) showed that the longer the children with ASD gazed at the service dog's head during
588 the presentation phases (phase 2 and 4), the more they paid attention to the service dog's
589 accessories during the free interaction phases (phase 3 and 5) with the service dog ($r=0.89$,
590 $p<0.05$); the longer they gazed at the parent's head during the presentation phases (phase 2 and
591 4) the less the parent initiated contact with the service dog during the free interaction phases
592 (phase 3 and 5) ($r=0.84$, $p<0.05$). Numbers of fixations on the parent's head were positively
593 correlated to vocalisations directed towards the service dog ($r=0.88$, $p<0.05$) and command
594 gestures towards the service dog ($r=0.88$, $p<0.021$). Similarly, the more the children with ASD
595 gazed at their parent's head during the presentation phases (phase 2 and 4), the more they gazed
596 at their parent during the interaction phase with the service dog (phase 3 and 5) ($r=0.88$,
597 $p<0.05$). The longer they gazed at the evaluator's head, the less they rejected vocally the service
598 dog ($r=-0.88$, $P<0.05$), and the less they paid attention to board games afterwards (phase 3 and
599 5) ($r=-0.94$, $p<0.05$). The more they gazed at the evaluator's head, the fewer they displayed
600 rejection gestures towards the service dog ($r=-0.890$, $p<0.05$).

601 Our data concerning inanimate/non-social targets (i.e. board games, service dog's accessories,
602 the rest of the scene) showed that the longer the children with ASD gazed at board games during
603 the presentation phases (phase 2 and 4), the more time they spent near (i.e. one arm distance)
604 their parent and stroked the service dog passively during the free interaction phases (phase 3
605 and 5) (all four tests, $r=0.850$, $p<0.05$). The more the children with ASD gazed at the service
606 dog's accessories during the presentation phases (phase 2 and 4), the more time they spent in
607 contact with the parent ($r=0.81$, $p=0.05$), and the less they initiated contact with the service dog
608 ($r=-0.94$, $p<0.017$) as well as they spent less time actively stroking the service dog ($r=-1.00$,

609 $p < 0.01$). Similarly, the more they gazed at the service dog's accessories during the presentation
610 (phase 2 and 4), the less they directed vocalisations towards their parent ($r = -0.94$, $p < 0.05$) and
611 expressed neutral vocalisations about the service dog ($r = -0.94$, $p < 0.05$) and the more they
612 displayed rejection vocalisations towards the service dog ($r = 0.88$, $p < 0.05$). The higher the
613 number of fixations on the service dog's accessories during the presentation phases (phase 2
614 and 4), the more children with ASD paid attention to board games ($r = -0.94$, $p > 0.05$), the less
615 they were in contact with the service dog ($r = -1.00$, $p > 0.01$), and the more they were further
616 from it during the free interaction phases (phase 3 and 5) ($r = -0.94$, $p < 0.05$). The more time the
617 children with ASD spent gazing at the AOI covering the rest of the visual scene during the
618 presentation phases (phase 2 and 4), the less they were subjected to their parent's vocalisations
619 moderating and correcting their interactions with the service dog ($r = -0.81$, $p = 0.05$; $r = -1.000$,
620 $p < 0.01$; respectively).

621

622

Discussion

623 Our aim was to explore the links between the visual attention of children with ASD to
624 animals, here future service dogs, and the interactions they had with them. In our study 1,
625 children with ASD displayed different interaction strategies with the service dog, which were
626 associated with different types of profiles of interactions with the service dog, and some of those
627 strategies correlated with children with ASD's visual behaviours (i.e. exploration of social items
628 versus objects) during interactions. In our study 2, children with ASD spent most of the time
629 exploring the service dog visually, particularly its head. We evidenced correlations between some
630 behaviour and the visual exploration variables, notably those reflecting attention to
631 animate/inanimate stimuli.

632 *Behavioural strategies and profiles of children with ASD interacting with a service dog*

633 Except for one child, all children with mild to moderate ASD interacted adequately with the
634 service dog, as previously described with pet dogs by parents (Carlisle, 2012). In our two studies,
635 children with ASD spent most of their time during the free interaction phases in physical contact
636 with the service dog. This contact was mostly active (i.e. petting the service dog while moving) and
637 initiated by the children. Furthermore, the most frequently displayed "care" behaviour included
638 physical contact with the service dog: brushing and giving it a kibble. A previous experiment by
639 Prothmann et al. (2009) showed that children with ASD prefer to interact with a therapy dog, notably
640 by stroking it or by initiating interactive games rather than with other social partners (i.e. adult
641 humans).

642 Of all the vocalisations and gestures we considered, the children with ASD used
643 preferentially command vocalisations and gestures towards the service dog during interactions with
644 it. This could be induced by two non-exclusive elements: the fact that the evaluator had previously
645 shown them these behaviours could suggest a form of imitation (skill that is present even if impaired
646 in ASD; Rogers & Pennington, 1991); children with ASD were encouraged by their parent to
647 practice these commands with the service dog. The valence of the other vocalisations was generally
648 neutral, while more rejection gestures than rejection vocalisations were observed. This could be
649 explained by the fact that non-verbal behaviours are subtler and not systematically associated with
650 vocalisations. For example, avoidance gestures which often resulted from unwanted contact with the
651 service dog or a specific service dog's body part (e.g. contact with the service dog's mouth or teeth,
652 service dog licking the child's face), probably caused by sensory disturbances often associated with
653 ASDs (Carlisle, 2012, Ben-Sasson et al., 2009). We confirmed that interactions between children
654 with ASD and service dogs – and larger with animals - are by essence multimodal (i.e. vocal, tactile,
655 visual), as previously observed during encounters with other animals (e.g. *guinea pigs*, Talarovičová
656 et al., 2010, Grandgeorge et al., 2012a, 2014, *therapy and pet dogs*, Prothmann et al., 2005,
657 Grandgeorge et al., 2020; *pet cats*, Grandgeorge et al., 2020, Hart et al., 2018). Amongst these

658 modalities of interactions, both children with ASD (*therapy and pet dogs*, Prothmann et al., 2005,
659 Carlisle, 2012; *guinea pigs*, Talarovičová, et al., 2010) and children with typical development
660 (Maurer et al., 2011; *pet dogs*, Filiatre et al., 1986) seem to prefer nonverbal interactions with
661 animals.

662 As previously observed, all children with ASD do not interact in the same way with
663 animals (Grandgeorge et al., 2014; *guinea pig*, Grandgeorge et al., 2012a; *service dog*, Dollion et al.,
664 submitted). They may deploy different strategies during an interaction and different profiles of
665 interaction between children with ASD and animals can be identified. Here, with the service dog,
666 children with ASD could be classified either in the first profile, "**tactile and visual contact with**
667 **service dog**" (tended to interact proximally with the service dog), or in the second profile, "**subjected**
668 **to parental supervision**" (interacting less proximally with the service dog), or in the third profile,
669 interacting more through "**vocal contact with the service dog**". These three profiles were similar to
670 others previously identified (i.e. "proximal and contact with the service dog", "distal and
671 command to the service dog", as well as "disinterest for the service dog"; Dollion et al.,
672 submitted) except that here, parental influence appeared more clearly. This could be easily
673 explained by the addition of some parents' behavioural items (e.g. parent vocalisations). Thus,
674 all children with ASD do not exhibit the same interest in a service dog. Visual attention appeared
675 to be a key element as the children with ASD with the "tactile and visual contact with service dog"
676 profile looked more at their parent, while those with the "subjected to parental supervision" profile
677 looked less at their parent. Looking at one's parent in a new situation may reflect an active search
678 for his/her interpretation, in order to use this evaluation to adapt his/her behaviour appropriately in
679 an ambiguous situation (i.e. social referencing) (Planche, 2010). Social referencing is known to be
680 poorly expressed by children with ASD and when they express it, they ignore the evaluative message
681 or take it into account only after a certain delay (Planche, 2010). However, the interspecific context
682 of interactions seems to facilitate the expression of social referencing for children with ASD. Indeed,

683 some children with ASD display many adult-oriented gazes during the first encounter with an
684 unfamiliar animal (*guinea pig*, Grandgeorge et al., 2012a). Children with ASD are also sensitive to
685 the direction of social attention as, in a situation of "social rivalry" (i.e. educator pays attention
686 to the child-dog dyad and then focuses his/her attention exclusively on the future service dog),
687 they adapt their visual attention (i.e. increased glances, glances and joint attention) aiming at
688 recovering the educator's and dog's attention that they had lost (Grandgeorge et al., 2017). In
689 line with social referencing (Deleau, 1999) we hypothesized that since they spent more time looking
690 at their parent(s), children with ASD with the "tactile and visual contact with dog" profile may have
691 gathered information from their parent(s) relative to their interpretation of the situation, which may
692 have lifted the ambiguity of the situation and promoted proximal interaction with the service dog. On
693 the contrary, since they paid less attention to their parent and spent more time looking at board games,
694 children with ASD with the "subjected to parental intervention" profile may not have benefited from
695 parental cues to lessen the ambiguity of the situation, and this could explain why they spend less time
696 interacting proximally with the service dog. However, in line with social referencing, we cannot rule
697 out that the opposite theory could be true: spending more time in contact with the service dog may
698 also cause more uncertainty for the child (i.e. unpredictable and new interaction partner), which
699 may have promoted the expression of social referencing behaviour towards parent(s). Furthermore,
700 an alternative hypothesis concerning children with ASD with the "subjected to parental supervision"
701 profile would be that since their parent was already very supportive vocally, these children may have
702 experienced less need to seek parental cues. However, this last hypothesis does not fit entirely with
703 the rational based on social referencing, since it predicts that children with ASD with the "subjected
704 to parental supervision" profile would have interacted proximally with the service dog more as they
705 received more parental cues and guidance.

706 *Visual exploration and interaction strategies with the service dog*

707 Animals are clearly an attractive visual target for children with ASD (Grandgeorge et al.,
708 2020; New et al., 2010; Prothmann et al., 2009). Here, children with ASD looked more frequently at
709 the service dog, especially at the dog's head. Previous studies using eye-tracking technology showed
710 that children with ASD paid greater visual attention to images of animal faces than to images of human
711 faces (*dogs*, Muszkat et al., 2015; *dogs, cats, horses*, Grandgeorge et al., 2016; *dogs, cats, horses,*
712 *cows*, Valiyamattam et al., 2020). Similarly, Prothmann et al. (2009) reported that children with
713 ASD clearly preferred interacting with a therapy dog to inanimate objects and humans. In view
714 of our results showing a high percentage of time children with ASD spent exploring the service dog
715 visually and in particular its head, one might have expected that this time would have varied between
716 our subjects and would have been associated with behaviours displayed during interactions with the
717 service dog. However, it appeared that all children with ASD looked at the service dog in a
718 homogenous way during the presentation phases (i.e. the service dog remained an attractive visual
719 target to children with ASD regardless of the behaviours displayed during the interaction). Indeed, the
720 time spent looking at the service dog was not associated with any subsequent behavioural tendency,
721 except that looking at the service dog's head was synonymous of more attention to the service dog's
722 accessories during the free interaction phases with it. No similar fact has been described previously.
723 Further investigation of this topic would be of interest in order to disentangle the meaning of
724 attention towards the service dog's accessories.

725 Looking at inanimate objects (i.e. board games and dog accessories) was associated with less
726 active stroking of the dog, but more passive stroking (i.e. no movement on the dog), and more time
727 spent close to their parent. Focusing on inanimate elements during the service dog's presentation
728 would mean that the child with ASD engaged less with the service dog during the interaction. This
729 phenomenon has been observed previously in some children with ASD during therapy sessions with
730 therapy dogs when interactions were characterized by little tactile contact and long periods of
731 distancing him/herself from the therapy dog with brief but glancing frequently at it (Prothmann et

732 al., 2005). The authors explained this by the fact that the dog remained unpredictable for the children
733 with ASD. From these observations, we may hypothesize that if children with ASD look less at a
734 service dog, they extract little information about it and thus, the service dog remains unpredictable
735 and less attractive to them. Differences in the meaning of gazes towards the service dog's
736 accessories during the free interaction and the presentation phases could explain the results
737 presented above. Indeed, the children with ASD may produce "care" behaviours while interacting
738 with a service dog, such as give it a kibble or water, which would require them to focus their
739 attention on the service dog's accessories. However, during the general introduction to the service
740 dog (including presentation of the dog, objects and commands), paying more attention to the
741 service dog's accessories may have another – non-exclusive - explanation. For example, this may
742 reflect a lack of general attention focus or a reduced interest in social stimuli or the novelty of
743 accessories may be more attractive than the service dog itself. Focusing on objects could also make
744 it easier for children with ASD to concentrate on the words of the evaluator, or reflect avoidance
745 of animate stimuli because of their unpredictable nature, which may generate anxiety (Grandin,
746 1995). Indeed, children with ASD have attentional orientation difficulties (O'Connor & Kirk,
747 2008), as well as concerning the perception of human biological movements (Blake et al., 2003).

748 Looking at the social agents (i.e. evaluator's and parent's head) was linked to interest and
749 interaction behaviours towards the service dog. Visual attention toward social agents has been
750 described in New et al's (2010) experiment in which both adults and children with ASD exhibit a
751 bias (attentional or preferential) towards animated stimuli (i.e. human and animal). However, our
752 study suggests a possible dichotomy around the initial attention towards animate/inanimate items
753 in relation to the behaviours expressed by the children with ASD during subsequent interactions
754 with a service dog (i.e. the more they looked at a social agent during the presentation phase, the
755 more they interacted with the service dog; the more they looked at inanimate items during the
756 presentation phrase, the more they expressed withdrawal and rejection behaviours). Although our

757 results are only exploratory, they could reflect that more than having a clear dissociation between
758 humans and animals, the initial general social skills that the children with ASD had might influence
759 the strategies they might be able to use during interactions with an animal. Indeed, our results seem
760 to show that the children with ASD's ability to gather information concerning social elements were
761 linked to interactions with the service dog. Based on those exploratory observations, a hypothesis
762 would that some general social skills applied to all social agents and altered by ASD might also be
763 involved when children with ASD interact with animals; even so animals may have a specific
764 status for people with ASD (Carlisle, 2014b). It would be of interest to investigate further this topic
765 by investigating whether social deficits affect interest in and interactions with animals, and if so, to
766 characterize which social deficits may be involved. Therefore, it appears that children with ASD's
767 abilities to gather information concerning social elements are involved in interactions with a service
768 dog, resulting in the same difficulties to engage in interactions. Indeed, social communication
769 difficulties intrinsic to ASD (i.e., absence/presence of verbal communication) have been
770 demonstrated to affect children with ASD's interaction with animals (*guinea pig*, Grandgeorge
771 et al., 2014).

772 ***Parental influence in service dog-children with ASD interactions***

773 During interaction with a service dog, children with ASD were more likely to be at some
774 distance from their parent(s). This observation may reflect a certain ease allowing them to interact
775 physically “alone” with the service dog or to initiate an activity without being close to their
776 parent(s). We cannot however rule out that this distancing from the parent may be caused by atypical
777 regulation of inter-individual comfort distances related to ASDs (Gessaroli et al., 2013).

778 When parents spoke to their children with ASD, they mostly encouraged them to interact with
779 the service dog rather than moderated their activity with the service dog. Interestingly, few reports
780 focus on the parental role in child with ASD and dog interactions. With a larger point of view
781 throughout studies about animal assisted interventions, as do therapists supporting children with

782 ASD's interactions with therapy animals, parents may have to promote and maintain their child's
783 engagement in activities with the service dog and help them to adjust their behavioural repertoire
784 (Redefer & Goodman, 1989). Previous reports showed that parents could influence the relationships
785 between the children with ASD and the animals indirectly (*guinea pig*, Grandgeorge et al, 2014; *pet*
786 *dog*, Carlisle, 2014b). Thus, exploring the influence of parenting style on children with ASD's
787 interactions with animals could be of great interest for future studies. This could be all the more
788 important because different parenting styles of parents of ASD children exist and they differ from
789 those of parents of neurotypical children (e.g. Boonen et al., 2015). We also observed that parental
790 guidance varied according to the children with ASD's behaviours during interactions with a service
791 dog. Indeed, children with the "subjected to parental supervision" profile (i.e. who received more
792 parental guidance) were the ones who also interacted less proximally with the service dog, gazed less
793 at their parent(s) and gazed more at board games. This result might reflect that parents adjust the
794 guidance provided to their children with ASD according to their behaviour, and more specifically,
795 according to their behaviour towards an animal and their visual attention.

796 ***Impact of age and ASD severity on the children's interaction with a service dog***

797 The older the children with ASD were, the more they interacted proximally with the service
798 dog, and the more they looked at it or at their parent (versus at board games or other items) during the
799 interaction. Similarly, the older the children with ASD were, the more time they spent looking at the
800 evaluator's head during the presentation phase. A similar increase in the time spent looking at peoples'
801 head with age in individuals with ASD has been described in previous studies (e.g., Kaliukhovich
802 et al. 2020). Thus, our study confirms that a child's age seems to be a critical factor that must be
803 considered when studying interactions between children with ASD and an animal. For example,
804 Grandgeorge et al. (2012a) reported that the children with ASD who went directly to the unknown
805 animal (i.e., *guinea pig*) were the oldest. At the same time, a child's age is also important for
806 neurotypical children in interaction with animals. Indeed, the older they are, the more they use verbal

807 interactions with animals, as adults do (e.g. *pet dogs*: Eckerlin et al., 1989; *pet cats*: Mertens &
808 Turner, 1988). It is important to note that, when controlling our data for children with ASD's age,
809 our results still highlight a significant link between visual attention and behavioural strategies during
810 the interaction with a service dog. Exploring the ontogeny of interactions between children with
811 ASD and animals, especially service dogs, could provide a great deal of elements of interests,
812 notably for organisms providing service for children with ASD.

813 Previous studies reported that the severity of symptoms may affect interactions with
814 animals (*service dog*, Dollion et al., 2019, submitted; *guinea pig*, Grandgeorge et al., 2014).
815 However, in the present study, this variable did not seem to impact either the behavioural strategies
816 adopted with the service dog or the orientation of gazes of the children with ASD towards the
817 service dog. This may be due to the fact that all the children included in our study had been
818 diagnosed with mild to moderate ASD, resulting in less variability in the spectrum, which might
819 have therefore lessened the effect of ASD severity.

820 *Limits, conclusion and perspectives*

821 Although our research demonstrated a link between visual attention of children with ASD and
822 their behaviour, our sample was relatively restricted. Therefore, these observations, especially our
823 second study, need to be replicated with a larger sample size, in order to improve the reliability of the
824 data and to confirm our results. Testing a larger sample would also allow gender comparisons, which
825 would be interesting as gender differences in neurotypical children-pets interactions are commonly
826 observed (*dogs, cats, birds, fishes*; Rost & Hartmann, 1994; *dogs, cats*, Kidd & Kidd, 1987). An
827 additional limitation would be that, for ethical reasons, all children with ASD included in the present
828 research had been preselected for service dog placement. This preselection was partly based on their
829 initial attraction to dogs. This recruitment constraint may have reduced inter-individual differences
830 concerning attraction to service dogs. Further studies should include deeper attention to the whole
831 body of social partners of the children with ASD. Indeed, because of the often-observed avoidance of

832 eyes, some children with ASD may have fixated the evaluator's body (i.e. bust) rather than his/her
833 face. Thus, delimiting our AOIs solely on the head of social agents may have had a limiting effect on
834 the data collected concerning attention paid to them.

835 To conclude, our research shows that a service dog is visually attractive and an attractive
836 interaction partner for children with ASD. Furthermore, all children with ASD did not show the same
837 interest in a service dog, and they had different types of strategies and interaction behaviors with it.
838 This study demonstrated a link between children with ASD's visual attention and their behaviour
839 during interaction. The results obtained by eye-tracking not only confirmed the existence of this link
840 but also seemed to indicate that the level of attention towards other humans (i.e. their parent(s) and
841 the evaluator) is associated with how children with ASD interact with an animal. We notably
842 observed that looking at their parent (as well as the evaluator [study2]) was associated with
843 children making more physical contact with the service dog and that parents seem to adapt the
844 support they provide to their child (i.e., here their vocalisations) according to the way their child
845 with ASD interacts with the service dog. Parents could thus be an important source of support
846 and guidance for children with ASD's interaction with an animal. Furthermore, these results
847 seem to indicate that considering the child attention towards social partners (i.e., his/her parent
848 and/or the evaluator) could be an additional element that service dog agencies may consider (on
849 top of the child's interaction with the dog) in their evaluation process for placement of a service
850 dog. It would be interesting to further these results by studying in finer detail how children with ASD
851 explore animal faces and bodies while interacting with them in "close to life" conditions.

852

853

Ethical concern

854 Both these studies were observational, non-invasive, and did not involve pharmacological
855 interventions for either the children with ASD or the service dogs. Both were performed in line
856 with the principles of the Declaration of Helsinki and both study protocols received approval

857 by the University of Montreal's Research Ethics committee in Education and Psychology
858 (Study 1: CERAS-2018-19-11-D; Study 2: CEREP-19-130-P).

859

860

Consent to participate

861 Informed consent was obtained from all individual participants included in the study. All
862 parents provided written consent to allow their child with ASD to participate in this study. All
863 children with ASD also provided their verbal and written approval for their participation.

864

Abstract

865 Two original studies explored relationships between visual attention of children with ASD
866 (candidates for receiving a service dog) and their behaviors during their first interaction with a
867 service dog. The first study consisted in video behavioural analyses of 16 children with ASD
868 interacting with a service dog. During the interaction with a service dog, the time children with
869 ASD spent looking towards social items vs objects was associated with how they interacted
870 with the service dog. The second study was exploratory (i.e. 6 children), using the same
871 behavioural approach but coupled with eye-tracking data. The more children with ASD looked
872 at both their parent and the evaluator, as opposed to inanimate items, the more they interacted with
873 the service dog.

874 **Keywords:** Autism Spectrum Disorder – Visual attention – Eye-tracking – Human–animal
875 interaction – Service Dog

876

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1068

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1081

1082 **Author Contributions**

1083 M.G., P.P. and N.D. developed the research project and designed the experiment; N.C., N.F.
1084 and N.D. organized the recruitment of subjects; N.C., N.F. and N.D. gathered the video
1085 database; M.T. and N.D. performed the analyses; M.G., M.T. and N.D. contributed to the
1086 statistical analysis; M.T., M.G. and N.D. wrote the manuscript and all authors proofread the
1087 final version of the manuscript.

1088

1089 **Competing Interests:** The authors declare that they have no competing interests

FOOTNOTE

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1091

1092 1- It is important to specify that dogs used in the present study were not service dog per se,
1093 since they were not dogs matched and living with a child (Solomon et al., 2010;
1094 <https://petpartners.org/learn/terminology/>; https://www.ada.gov/service_animals_2010.htm),
1095 but were dogs by the end of their training and on the edge of becoming service dogs. However,
1096 for the sake of clarity, we will label them as service dogs in the rest of the manuscript.

FIGURES AND TABLES**Figures captions**

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Figure 1: Observation procedure: the 5 evaluation phases in studies 1 and 2. Eye-tracking glasses were worn in addition during phases 2 and 4 in study 2. Times refer to the ideal durations of the different phases: during studies 1 and 2, the average durations of phases 3 and 5 were 552.0 ± 54.0 and 582.0 ± 106.8 seconds respectively; and during study 2 the average durations of phases 2 and 4 were 108.7 ± 25.8 and 174.0 ± 44.8 seconds respectively).

Figure 2: Group distribution on the factors extracted from the PCA: average scores for each group on the factors (\pm SE). The more the score was positive, the more the behaviours positively related to that factor were expressed. Data that do not share a common letter differed significantly at $p > 0.05$ (Kruskall Wallis tests followed by Dunn tests). White bars: “Tactile and visual contact with service dog” children’s profile (Group 1); black bars: “Subjected to parental supervision” children’s profile (Group 2); grey bars: “Vocal contact with the service dog” children’s profile (Group 3).

Figure 3: Gaze orientations in relation to the profile of children with ASD (mean $\% \pm$ SE). Horizontal dashed lines represent the mean percent of the three groups for that variable. Data that do not share a common letter differed significantly at $p < 0.05$ (Kruskall-Wallis tests followed by Dunn tests). White bars: “tactile and visual contact with service dog” children’s (Group 1); black bars: “Subjected to parental supervision” children’s profile (Group 2); grey bars: “Vocal contact with the service dog” children’s profile (Group 3).

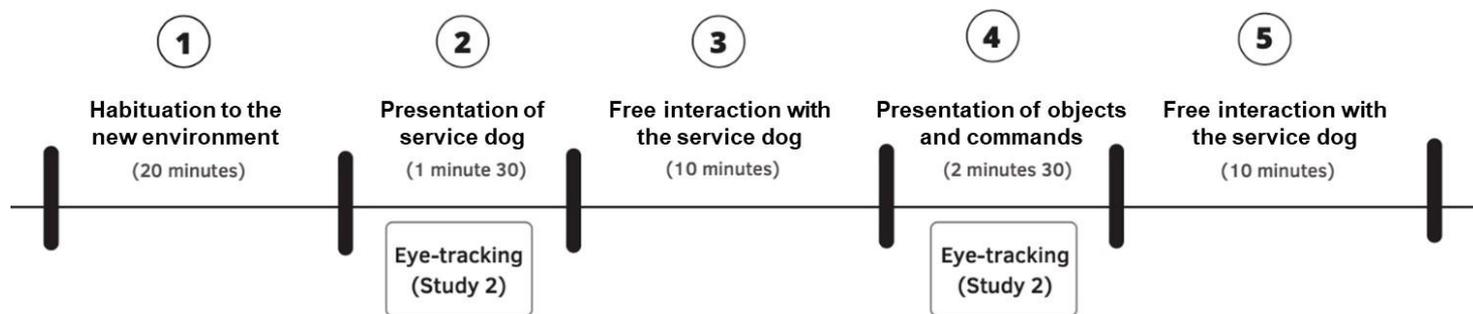
1121 Figure 4: Oculometric movement data of children with ASD for AOIs targets: (A) Mean
1122 fixation times (%) on the 7 AOIs targets (black bars); (B) Mean numbers of fixations by the
1123 children with ASD on the 7 AOIs targets. Grey bars: fixation on the service dog's head AOI,
1124 which was included in fixation on the service dog AOI. Therefore, this comparison was not
1125 analysed statistically. For clarity and for comparisons between data for the service dog's head
1126 and the other variables (excluding the service dog), and between data for the entire service dog
1127 and the other variables (excluding service dog's head), a common letter was assigned to these
1128 two dog AOI. Data that do not share a common letter differed significantly at $p < 0.05$ (Kruskall-
1129 Wallis test and Dunn test).

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Figures

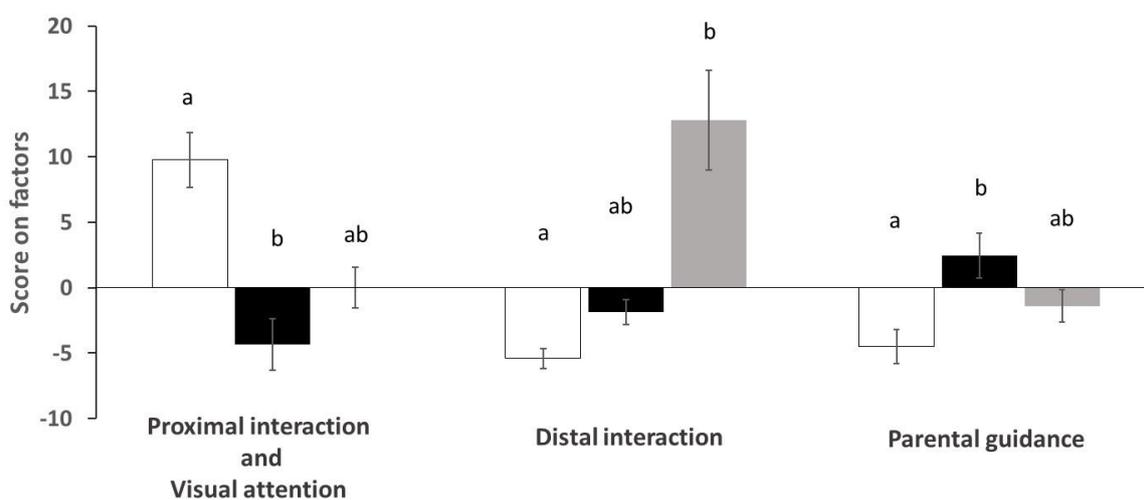
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Figure 1



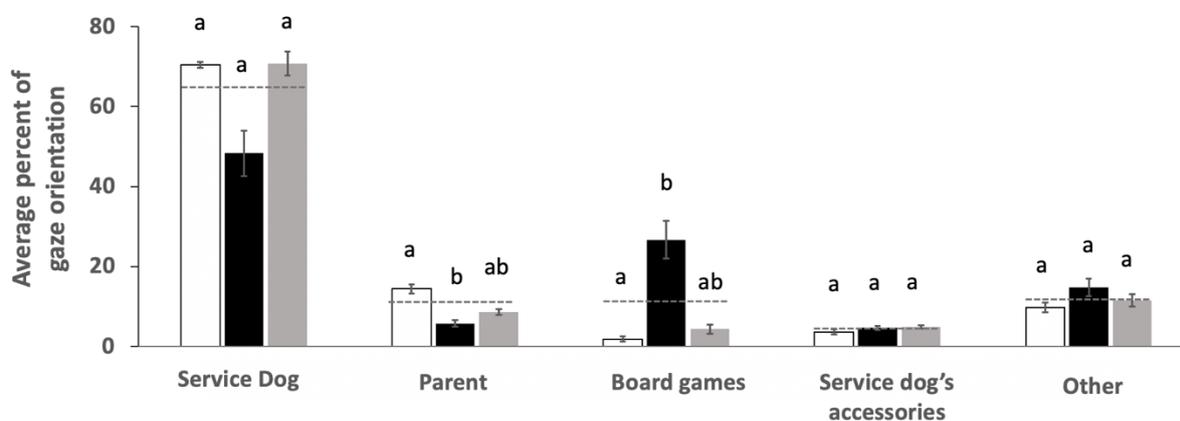
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Figure 2



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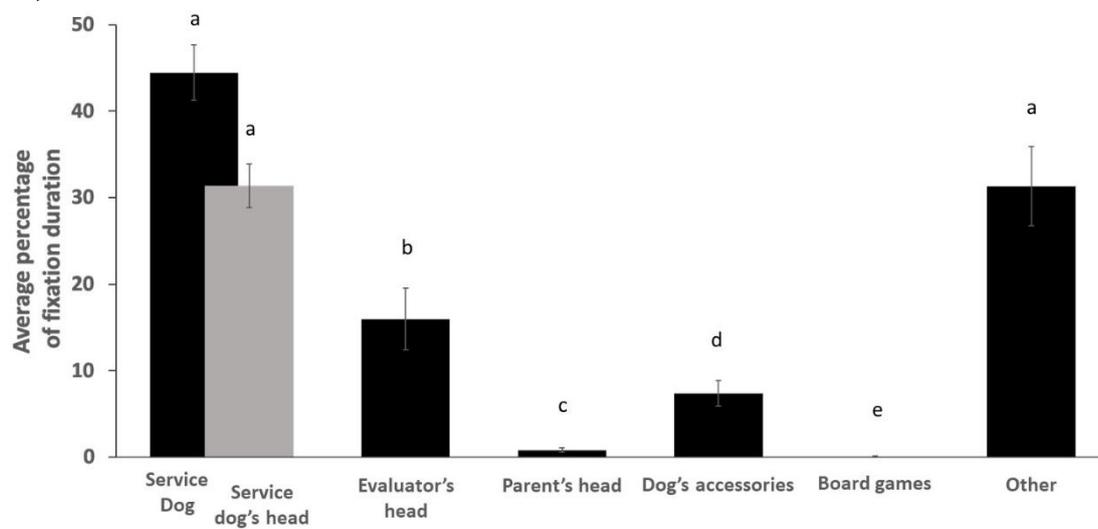
Figure 3



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1142 *Figure 4*
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A)



B)

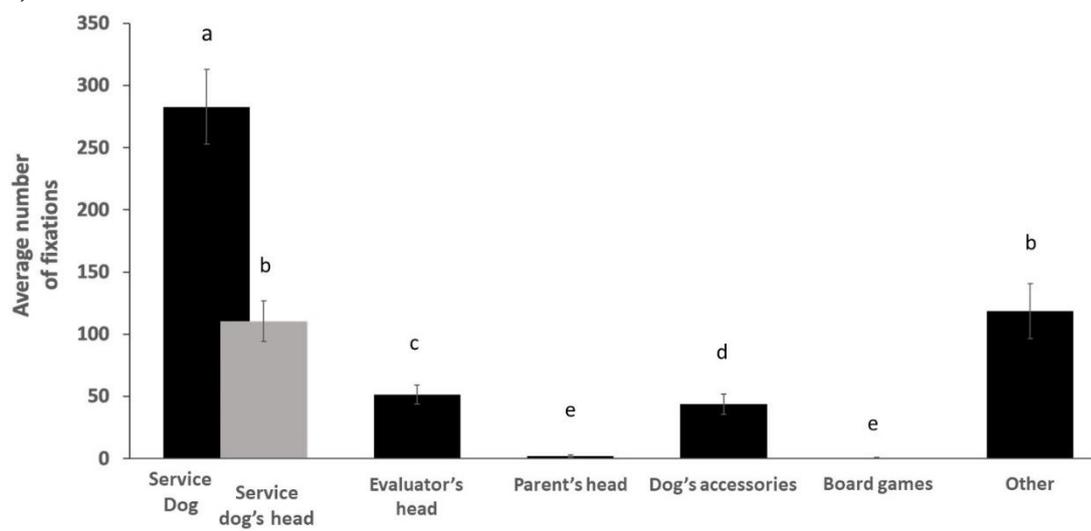


Table captions

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1146 Table 1: Definitions of the behavioural items analysed

1147

1148 Table 2: Behaviours displayed by children with ASD during interaction with the service dog.

1149 A) Behaviours recorded by focal sampling (mean numbers of occurrences, except type of

1150 contact (i.e. passive/active stroke)) that was estimated in seconds (mean total duration); and B)

1151 frequencies of behaviours recorded by scan sampling (percent of scans). Level of significance:

1152 $p < 0.05$ (Friedman tests).

1153

1154 Table 3: Contribution of each behavioural variable to the PCA factors (i.e. scores of variables

1155 on the factors). Variables were considered to support factor information when the value was

1156 greater than 0.5 and are in bold characters.

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Tables

1159 *Tables 1*

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Behavioural category	Definition	Subtypes and behaviours
Child with ASD's contact with service dog	Any area of a child's and service dog's body that come into physical contact.	<i>Contact initiator:</i> child with ASD, service dog, parent <i>Type of contact:</i> active, passive (i.e. presence or absence of movement from the area of the child in contact with the service dog; adapted from Katcher et al., 1979; in Katcher, 1981). <i>Nature of contact:</i> direct (contact without an object) or indirect (contact through an object)
Vocalisation of child with ASD	Any child's vocalisation concerning the service dog or related to it.	<i>Directed to:</i> the service dog, the parent(s) <i>Nature of vocalisations:</i> service dog's name, command, vocalisation expressing attraction to* or rejection of the service dog**, and neutral vocalisations about the dog**. * <i>Attraction vocalisations</i> = all vocalisations emitted by the child with ASD reflecting an interest or a willing to get in contact with the service dog, a positive affect in the contact with it, a positive comment towards it or paraverbal vocalisations expressing positive affects toward the service dog (ie.g., laugh, positive exclamation or excitement, giggles). ** <i>Rejection vocalisation</i> = all vocalisations emitted by the child with ASD reflecting an absence of interest or an unwillingness to get in contact with the service dog, a negative affect in the contact with it, a negative comment towards it or paraverbal vocalisations expressing negative affects toward the service dog or the contact with it (e.g., scream, disgust vocalisation ["eww"]). *** <i>Neutral vocalisation</i> = all vocalisations emitted by the child with ASD reflecting neither an attraction nor a rejection, such as describing the service dog, describing an ongoing action with the service dog, verbally presenting an object to the service dog and so on.
Vocalisation of parent	Any vocalisation emitted by the parent(s) regarding the interaction between the child and the service dog	<i>Nature of vocalisations:</i> (1) encourage interaction with the service dog, (2) moderate or curb the activity initiated between the child and the service dog, (3) rectify the activity initiated by the child.
Child with ASD's gesture towards service dog	Any gesture made by the child towards the service dog	<i>Nature of gestures:</i> command, gesture expressing attraction to or rejection of the service dog, inappropriate, other types of gestures, attempt to contact the service dog (i.e. approaches the dog with part of his/her body but withdraws just before making contact).
Distance between child with ASD and service dog	Distance between the closest part of the child's body part and the service dog	Direct contact or indirect contact, ½ arm (length), 1 arm, 1½ arm, further away.
Distance between child with ASD and parent	Distance between the closest part of the child's body part and the parent (closest parent if more than one)	Direct contact or indirect contact, ½ arm (length), 1 arm, 1½ arm, further away.
Gaze orientation of child with ASD	Global orientation of head and gaze	<i>Directed towards:</i> parent, service dog, board games, service dog's accessories (i.e. brush, water bowl, kibble box), other directions (i.e., when the child's gaze is not oriented towards any of the identified targets).
Care behaviour by child with ASD	All care behaviours expressed by the child concerning the service dog	Brushes the service dog, gives it water, gives it a kibble, holds its leash, other types of care (diverted use of the object), or unsuitable care (e.g. violent).

1161 *Table 2***A) Behaviors collected in focal sampling**

		Mean	SE	Friedman test
Child with ASD's contact with service dog	Initiated by the service dog	8.1	1.5	$F=22.6$ $p<0.001$
	Initiated by the child with ASD	32.3	3.5	
	Initiated by the parents	3.3	0.8	
	Passive stroke	58.0	12.1	$F=9.0$ $p=0.003$
	Active stroke	226.3	57.1	
Vocalisation of child with ASD's	Attraction	22.5	4.1	$F=37.8$ $p<0.001$
	Rejection	3.6	1.3	
	Service dog's name	27.0	6.4	
	Neutral	34.4	4.0	
	Command	46.8	11.0	
Vocalisation of parent's	Directed to the service dog	102.9	20.2	$F=28.5$ $p<0.001$
	Directed to the parents	31.3	3.2	
	Directed to other	0.1	0.1	
Vocalisation of parent's	Encourage	23.4	3.3	$F=24.0$ $p<0.001$
	Curb	4.7	1.3	
	Rectify	12.4	2.1	
Child with ASD's gesture towards service dog	Attraction	4.4	1.4	$F=57.7$ $p<0.001$
	Rejection	4.0	1.1	
	Command	37.2	10.4	
	Others	0.7	0.3	
	Attempt	0.5	0.2	
	Inappropriate	0.1	0.1	

B) Behaviors collected in scan Sampling

		Mean	SE	Friedman Test
Distance between child with ASD and service dog	Contact	22.4	4.2	$F=25.6$ $p<0.001$
	0.5	29.2	2.5	
	1	12.5	1.3	
	1.5	9.6	1.1	
	More	26.3	3.2	
Distance between child with ASD and parent	Contact	4.6	1.7	$F=38.1$ $p<0.001$
	0.5	26.4	3.5	
	1	15.3	1.9	
	1.5	12.0	1.4	
	More	41.8	4.4	
Gaze orientation of child with ASD	Service dog	58.1	5.2	$F=33.4$ $p<0.001$
	Parents	8.4	1.3	
	Board games	16.2	4.6	
	Service dog's accessories	4.4	0.5	
	Other	12.9	1.9	
Care behaviour by child with ASD	Giving a kibble	28.0	5.8	$F=4.2$ $p>.05$
	Brushing the service dog	32.0	5.8	
	Keeping on a leash	28.4	6.6	
	Giving water	11.7	1.8	

1162

1163 *Table 3*

Behavioural Categories		F1 Proximal interaction and visual attention (PIVA)	F2 Distal interaction (DI)	F3 Parental guidance (PG)
Child with ASD's contact with service dog	Initiated by the service dog	-0.296	0.101	<0.100
	Initiated by the child with ASD	0.84	0.161	-0.198
	Initiated by the parents	0.23	-0.115	0.648
	Passive stroking	<0.100	-0.114	-0.38
	Active stroking	0.789	-0.385	-0.126
Vocalisation of child with ASD	Attraction	0.472	0.475	-0.397
	Rejection	-0.345	<0.100	0.166
	Service dog's name	<0.100	0.802	0.16
	Neutral	0.592	0.187	-0.42
	Command	0.148	0.921	<0.100
	Directed to the service dog	0.14	0.945	<0.100
	Directed to the parents	0.732	-0.377	-0.2
Vocalisation of parent	Encourage	<0.100	-0.281	0.777
	Curb	<0.100	<0.100	0.759
	Rectify	-0.257	0.211	0.587
Child with ASD's gesture towards service dog	Attraction	-0.229	0.661	-0.113
	Rejection	-0.259	0.203	0.443
	Command	0.223	0.839	0.172
	Others	-0.196	0.827	-0.206
	Attempt	0.362	-0.252	<0.100
Distance between child with ASD and service dog	Contact	0.859	-0.341	-0.129
	0.5	<0.100	0.238	0.601
	1	-0.32	0.477	0.187
	1.5	-0.387	<0.100	<0.100
	More	-0.813	<0.100	-0.384
Distance between child with ASD and parent	Contact	<0.100	-0.17	0.723
	0.5	0.234	-0.497	0.376
	1	<0.100	-0.409	<0.100
	1.5	0.158	<0.100	-0.404
	More	-0.252	0.648	-0.46
Gaze orientation of child with ASD	Service dog	0.843	0.332	0.209
	Parents	0.575	-0.13	-0.436
	Board games	-0.813	-0.274	<0.100
	Service dog's accessories	-0.233	<0.100	<0.100
	Other	-0.638	-0.153	-0.252
Care behaviour by child with ASD	Gives the service dog a kibble	0.309	0.658	0.228
	Brushes the service dog	0.571	-0.484	-0.266
	Keeps it on a leash	0.207	-0.181	0.341
	Gives it water	0.307	0.121	0.15
Eigenvalue		7.679	7.265	5.028
Percentage of cumulated variance		19.7 %	38.3 %	51.2 %

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