Article

Equine Assisted Activities (EAA) for Children with Autism Spectrum Disorder (ASD): Positive Effects Revealed Using an Ethological Approach

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Abstract: Equine Assisted Activities (EAA) are considered a suitable innovative rehabilitative practice for children with neurodevelopmental disorders, including Autism Spectrum Disorder (ASD). While standardized scales have been previously used as a tool to evaluate the effects of EAA on different domains of functioning in ASD children, few studies have considered an ethological approach as a means to describe human-horse interactions in the context of ASD. In this study, we aimed to evaluate the behaviour of 19 children with ASD - in comparison with 19 typically developing children (TD) - during EAA sessions. We developed an ethogram from the video-recordings, to assess spatial relationships, social interactions and communicative behaviours displayed by the child towards the horse, as well as the occurrence of problem behaviours. Results indicate that children's behaviours during EAA sessions are modulated by sex and age, while previous children's experience with EAA appeared to improve interpersonal distance and horse handling. Results from this study highlight the importance of exploring children's behavioural response during animal-assisted activities through direct measurements. This may allow linking the quality/strength of the child-horse relationship to the benefits obtained by the child, particularly in the social/communicative domain, a core symptom of ASD.

Keywords: Equine-assisted activities; Autism spectrum disorder; Ethogram; Social interactions; Communicative behaviours; Problem behaviours

1. Introduction

Research reporting relevant effects of human-animal interaction on human health is rapidly growing [1]. Animal-Assisted Activities with horses - also known as Equine Assisted Activities (EAA) - include mounted riding activities or ground activities such as grooming and stable management. EAA represent complementary approaches that have been shown to exert positive effects on social, emotional and physical domains for persons with physical or mental disabilities [2–4]. It has been recently hypothesized that, owing to their particular communicative skills, horses may react to human emotional states by modifying their own behaviour (emotional transfer mechanism). Such an emotional tuning may depend upon the synchronization of physiological activities, such as cardiovascular, hormonal or behavioural function, forming the basis for the positive effects of EAA on human health [5–7].

In addition to the emotional relationship that is established with the rider, the horse stimulates the rider's body simulating human gait thus improving flexibility, balance and muscle strength, providing important motor stimulation. The positive effects of motor stimulation, together with

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recreational opportunities for individuals that enjoy the activity outdoors make EAA especially suitable to improve patients' overall quality of life [8].

Having the potential to stimulate multiple areas of functioning, EAA has been considered a suitable innovative rehabilitative practice for children with neurodevelopmental disorders [9]. Autism Spectrum Disorders (ASD) represent a heterogeneous group of neurodevelopmental disorders characterized by impairment in social communication and social interaction (e.g. deficits in social-emotional reciprocity; deficits in non-verbal communicative behaviours; deficits in developing, maintaining and understanding relationships), repetitive and unusual sensory-motor behaviours (e.g. stereotyped or repetitive motor movements, hyperreactivity or hyporeactivity to sensor input) [10]. The multifactorial nature of ASD necessitates a multi-faceted therapeutic approach and EAA may complement other interventions that children with ASD are exposed to, including educational/behavioural therapies and pharmacotherapy [8,11].

Social deficits represent the core impairment in individuals with autism and the inclusion of an animal as a complementary approach for children with ASD is motivated by the fact that an animal may act as a social facilitator, improving children's social skills [12,13]. Reported positive outcomes of EAA for the ASD population include effects on mood [14], reduction in problem behaviours such as irritability, lethargy, stereotypy, hyperactivity [15], aggressiveness [16], improved physical, emotional and social functioning [4,9,13,17–24], improved executive functioning [9] and improved postural stability [25].

The evaluation of the effects of EAA on ASD children's behaviour has so far relied on surveys and scales, mostly filled by parents and/or therapists before and after the EAA sessions [2,4,9,13–15,21,22,26]. Direct behavioural observation using an ethogram obtained from the video-recordings is considered more objective than surveys and scales but, so far, few studies have used an ethological approach to assess human-horse interactions in children with ASD [27–33].

In this study, we aimed to evaluate the behaviour of 19 children with ASD - in comparison with 19 typically developing children (TD) - during EAA sessions and to explore the effect of other child-related factors, namely sex, age and experience with the horse. To this aim, we developed a specific ethogram to collect information on children's communicative/relational style during EAA sessions, as well as any occurrence of problem behaviours shown by children.

2. Materials and Methods

2.1. Ethical Statement

The methods and procedures of this study were in accordance with Italian legislation (D.L.vo n. 26 of 04th March 2014) on the protection of animals used for scientific purposes (Authorization n°1055/2015-PR). Owners of horses gave written consent to the enrolment of their animals in the study. Moreover, parents of participants signed informed written consent for the involvement of their children in riding sessions, and all data about their children were processed in compliance with privacy and data protection law. The research protocol was approved by the Ethics Committees of the Istituto Zooprofilattico Sperimentale delle Venezie (EC protocol number 6/2014) and the Istituto Superiore di Sanità (Prot. PRE-790/15).

2.2. Participants

2.2.1. Children

A total sample of 38 children (12 females and 26 males) was selected for the study (see **Table 1** for children's characteristics). Of 38 children, 19 had a previous diagnosis of ASD (4 females and 15 males) and 19 serve as a control group (TD children; 8 females and 11 males). All children were aged between 5 and 17 years old. Children with ASD were characterized by IQ scores ranging from 60 to 80 according to WISC III test, a psychometric test exploring different dimensions of intelligence [34].

Children were selected among those who attended the riding centers participating in the study and they were divided into two groups according to their experience in EAA: i) less than 1 month of

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experience (n ASD=9; n TD=7); ii) more than 1 month of experience in EAA (n ASD=10; n TD=12). The exclusion criteria were animal allergy symptoms and/or fear of children for horses.

Table 1. Characteristics of participants (n=38)

Riding Center	Child number	Diagnosis	Sex	Age (years)	EAA Experience (months)
Center 1	1	TD	M	17	> 1
	2	TD	M	11	> 1
	3	TD	M	8	> 1
	4	TD	M	6	> 1
	5	ASD	M	13	> 1
	6	ASD	M	8	> 1
	7	ASD	M	9	> 1
	8	ASD	M	6	≤ 1
Center 2	9	TD	F	9	> 1
	10	TD	M	8	> 1
	11	TD	M	9	> 1
	12	TD	M	9	> 1
	13	ASD	F	8	> 1
	14	ASD	F	11	> 1
	15	ASD	M	na	> 1
	16	ASD	M	8	> 1
Center 3	17	TD	F	7	≤ 1
	18	TD	F	10	> 1
	19	TD	F	9	> 1
	20	TD	F	7	> 1
	21	TD	F	9	> 1
	22	TD	F	7	≤ 1
	23	ASD	F	10	> 1
	24	ASD	M	7	≤ 1
	25	ASD	M	6	≤ 1
	26	ASD	M	10	≤ 1
	27	ASD	M	17	> 1
	28	ASD	M	11	> 1
Center 4	29	TD	F	6	≤ 1
	30	TD	M	9	≤ 1
	31	TD	M	6	≤ 1
	32	TD	M	na	≤ 1
	33	TD	M	10	≤ 1
	34	ASD	F	7	≤ 1
	35	ASD	M	8	≤ 1
	36	ASD	M	5	≤ 1
	37	ASD	M	6	≤ 1
	38	ASD	M	na	≤ 1

Abbreviations. TD, Typically Developing; ASD, Autism Spectrum Disorders; EAA, Equine Assisted Activities; na, not available

2.2.2. Horses

A total of 19 horses were selected for the current study. They were all between 8 and 26 years old, 13 horses were geldings and 6 were mares. They were of different breeds, were recruited from 4

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Italian riding centers, and no foals were chosen. All horses were specially trained for EAA with an average of 5 years of experience in EAA (**Supplementary Table 1**). The horses were of medium size, in a good state of health, and suitable for morphology, biomechanics and behaviour. The horse's health was guaranteed by a veterinarian specialized in equestrian rehabilitation for the entire duration of the study, taking into account health care, living conditions, work schedules and equipment requirements.

2.3. Procedures

2.3.1. Settings

The EAA sessions took place at four certified Riding Centers: a) Centro di Riabilitazione Equestre "Vittorio di Capua", Azienda Ospedaliera Niguarda Ca'Granda, Milano; b) Il Grande Ranch, San Francesco al Campo, Torino; c) Centro Ippico Meisino, Torino; d) A.S.D Equitazione per tutti Onlus, Fiumicino.

The riding instructors were different in the different centers. Thus, in order to harmonize and standardize all procedures, we included only Riding Centers with the same working standard and approach, as well as high standards for the welfare/health of animals employed. Moreover, all the riding instructors have followed the same training program according to Italian National Guidelines for Animal-Assisted Interventions [35].

In order to further guarantee that the therapeutic sessions were homogenously delivered, before the beginning of the study, all riding instructors attended preliminary meetings with the researchers and were provided with both written and video materials (a DVD appositely prepared) describing the session to be delivered. The therapeutic setting included the patient, the horse, a certified horse handler and a therapist; the same team was involved in all sessions according to Italian National Guidelines for Animal-Assisted Interventions [36]. The settings included fences, stalls, arenas, halters, ropes, bridles, and hitching areas all designed to contain horses and manage their behaviour.

2.3.2. EAA sessions

Therapeutic sessions with horses were carried out in the Riding Centers during the winter season (Nov 2015 – Jan 2016). All sessions were carried out between 2:00 pm and 4:00 pm and they were conducted by means of a standardized procedure adapted from Borgi and colleagues [9]. The session duration was about 30 minutes and followed the protocol described in **Table 2**. Each horse was involved in two EAA sessions: one day with a child with ASD and the day after with a TD child (the order of sessions was counterbalanced among horses).

Table 2. Session description (phases, duration and activities performed)

Phase	Time (min)	Activities
Grooming	5′	Child's knowledge of the horse (morphology, behaviour); first contact; main security rules; grooming techniques and saddling.
Horse at hand	5′	The child leads the horse with a lead rope around the arena.
Mounting	-	The horse stops and the child mounts the horse.
Riding exercises	10′	Learning riding basic elements (walk); performing exercises while riding the horse at walk (rotating/bending, outstretching upper arms and trunk).
Stationary exercises/Games	5′	Performing exercises on the horse (horse halted); games such as rods, cones or balls are used.
Dismounting	-	The child dismounts.
Reward	5′	The child rewards the horse with something to eat (e.g. carrot, sugar, hay) and greets him.

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2.4. Behavioural analysis

2.4.1. Data collection

All sessions were filmed with Sony cameras (Handycam DCR-SX21E). Behavioural analysis was performed using a focal sampling method (Altmann. 1974) and a dedicated software (BORIS) (Friard & Gamba 2016).

2.4.2. Children's behaviours during EAA

Videos of the sessions were subsequently scored to record children's behaviours during therapeutic sessions. An ethogram was developed to assess children's spatial relationships with the horse, social and communicative behaviours with the horse, as well as children's problem behaviours during the EAA sessions. Relevant literature was reviewed, taking into account both studies on human-animal interaction [27,28,37–39] and on behaviour of children with ASD [40]. The complete ethogram is shown in **Table 3.** Recorded behaviours include: spatial relationship (**Table 3a**), social interactions and communicative behaviours displayed by the child towards the horse (**Table 3b**) and problem behaviours (**Table 3c**). Behaviours of children were categorized as state events or point events; a state event describes behaviours that have a duration, while a point event represents behaviours that are too fast to be noted as a state event (they don't have duration) [41]. Duration and frequency of behaviours were expressed, respectively, as minutes spent performing the behaviour and as the number of occurrences of that behaviour out of the total time observed (in minutes). The total time observed was computed taking into consideration the time intervals in which the child was out of field of view of the camera.

Table 3. List of child's behaviours scored during the EAA sessions (ethogram)

Behaviour	Description	Mode
a) Spatial relationship (interpersonal distance)		
Closeness	The child stays at a short distance from the horse (≤ contact distance).	State
Withdrawal Avoidance	The child walks away from the horse (*to be categorised as 'Withdrawal' it must end 'Closeness'*) or refuses to interact with the horse when solicited, by turning the whole body around its axis (or turning the face away) more than 90°.	Point
b) Social interactions and communicative behaviours		
Grooming	The child brushes/cleans the coat of the horse (with tools).	State
Physical contact	The child establishes positive physical contact with the horse (not work-related), e.g. petting, stroking the horse (without suitable equipment), lying down on the horse, kissing the horse, head-contact with the horse's head, neck, back or rump.	State
Visual contact	The child looks, i.e. directs her/his gaze (looks at, turns the head) towards the head/eyes of the horse or extends the hand/arm in the horse's direction (not touching), e.g. to allow the horse to sniff the hand.	Point
Emotional behaviours	The child changes facial expression by turning up the corners of the mouth/spreading the lips and the mouth is closed or slightly open (smile) or smiling while making sounds with voice (laugh) [Child's face is turned towards the horse].	Point
c) Problem behaviours		

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Distraction	The child is not interested in the session (e.g. looking around, interested in objects, etc).	Point
Motor stereotypy	The child displays repetitive, relatively invariable sequences of behaviour with no obvious function including: rock (rhythmic up-and-down movements, either in a lateral or dorsal-ventral way); flapping (stereotyped hand-flapping); jump (abruptly raises body with or without feet leaving the floor; does not include skipping, galloping or dancing); tiptoe (the child walks on toes); clap (claps hands repetitively out-of-context); finger (moves fingers in a flicking motion, often near the head); spin (rotating the body around own axis repetitively and out-of-context); head spin (rotates the head around own axis repetitively and out of context); nod (moves the head up and down several times); shake (rotates head from side to side several times).	Point
Other problem behaviours	The child displays other problem behaviours including screaming, crying, stamping foot near the animal, auto-aggression/self-injury (the child hurts own body, e.g., scratching skin, pulling the hair, biting hand, banging head against something), hetero-aggression (the child physically hurts another person or the horse, e.g., hair pulling, kicking, punching, biting, scratching, hitting with fists, hands or whips), auto manipulation (the child manipulates own body, e.g. finger against teeth, picking nose or teeth), covering eyes/ears with own hands, vocalizations (the child produces an unintelligible sound with mouth).	Point

2.5. Data management and Statistical analysis

Regarding the analysis of children's behaviours during EAA, non-parametric statistical tests were applied since most of the dependent variables (children's behaviour as described in Table 3) deviated from a normal distribution (checked with the Shapiro-Wilk normality test). Frequency/duration of behaviours (spatial relationships, social interactions and communicative behaviours, problem behaviours) shown by children with ASD vs.TD and by children of different sex (male and female), age (5-9 years old and 10-17 years old) and EAA experience (≤1 month vs >1 month) were compared by means of a series of Mann-Whitney tests (two groups compared) and Kruskal-Wallis tests (more than two groups compared). Post-hoc analysis was carried out using Dunn's Test with the significance level adjusted to 0.013 (0.05/4) in the case of four planned comparisons. Data were analysed with Statview II (Abacus Concepts, Berkeley, CA, United States) and IBM SPSS Statistics for Windows, Version 27.0 (Armonk, NY: IBM Corp).

3. Results

Main effect of diagnosis, sex, age and EAA experience on children's behaviours

We assessed the effect of diagnosis (ASD vs. TD) on children's behaviours shown during EAA. Analyses with Mann-Whitney test showed that children with ASD spent significantly less time in physical contact with horses than children with TD (U= 59.000, p=0.0004) and displayed significantly less visual contact towards the horses than children with TD (U=70.000, p=0.0013). By contrast, children with ASD showed a higher frequency of withdrawal/avoidance from the horse (U=92.000, p=0.0098) and of problem behaviours (U= 19.000, p<0.0001) than TD children. For other behaviours, no significant differences were observed (all Us> 135.000, all ps>0.05).

As for the effect of the sex (female vs. male), analyses with Mann-Whitney test showed that female children stayed at a shorter distance from the horse (closeness; U=77.000, p=0.0131) and showed a lower frequency of problem behaviours than male children (U=79.000, p=0.156). For other behaviours, no significant differences were observed (all Us> 137.000, all ps>0.05).

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We didn't observe significant effects of age (5-9 years vs. 10-17 years) on children's behaviours shown during EAA (all Us> 77.000, all ps>0.05).

Children with more experience in EAA (> 1 month *vs* ≤ 1 month) stayed at a shorter distance to the horse (closeness; U= 40.000, p<0.0001) and showed more grooming of the horse (U=38.000; p<0.0001) than children with less EAA experience. For other behaviours, no significant differences were observed (all U_s> 150.500, all p_s>0.05).

3.1. Effect of the interaction between diagnosis and sex on children's behaviours

We assessed the interaction effect between diagnosis (ASD vs. TD) and sex (F vs. M) on children's behaviours during EAA. Analyses with Kruskal-Wallis test showed a significant interaction effect on the frequency of withdrawal/avoidance behaviour (H(3)=9.692, p=0.0214), visual contact (H(3)=12.596, p=0.0056) and problem behaviours (H(3)=24.163, p<0.001), as well as on the duration of physical contact (H(3)=13.836, p=0.0031).

More in particular, post hoc analysis (Dunn's Multiple Comparison Test; four planned pairwise comparisons; level of significance set at 0.05/4=0.013) showed that the higher frequency of withdrawal/avoidance from the horse shown by ASD children in comparison to TD children (main effect) was due to female children (p=0.005; **Figure 1a**) while no difference was found between ASD and TD male children (p=0.180).

The lower frequency of visual contact towards the horses shown by ASD children in comparison to TD children (main effect) was due to male children (p<0.001; **Figure 1b**) while no difference was found between ASD and TD female children (p=0.520). Likewise, the lower duration of physical contact with horses shown by ASD children in comparison to TD children (main effect) was due to male children (p=0.002; **Figure 1c**) while no difference was found between ASD and TD female children (p=0.054).

Moreover, the higher frequency of problem behaviours shown by ASD children in comparison to TD children (main effect) was due to male children (p<0.001) while no difference was found between ASD and TD females (p=0.025).

For other behaviours, no significant differences were observed (all H_s(3)< 7.441, all p_s>0.05).

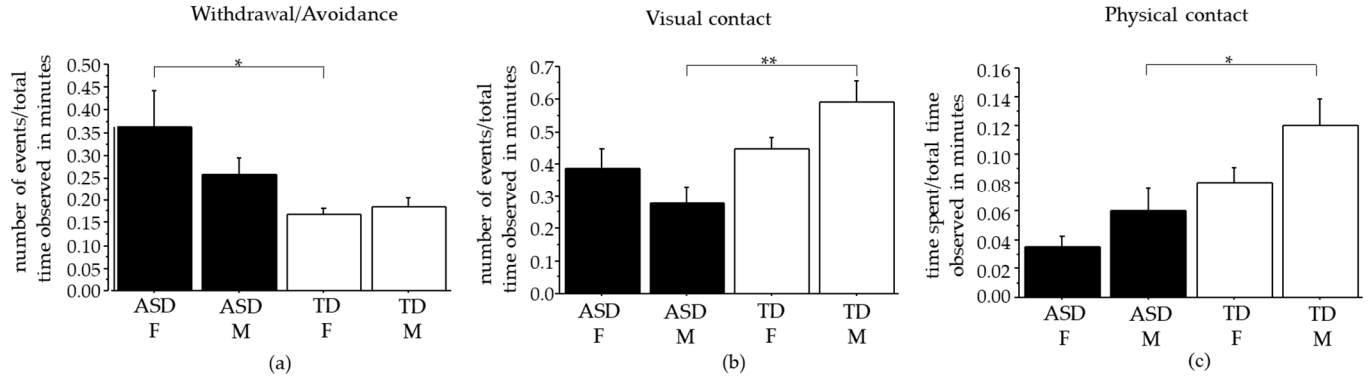

Figure 1. (a) Frequency (number of events/total time observed in minutes) of withdrawal/avoidance; **(b)** frequency of visual contact; **(c)** duration (time spent/total time observed in minutes) of physical contact in female (F) and male (M) ASD children (black bars) and TD children (white bars); *p<0.01; **p<0.001.

3.2. Effect of the interaction between diagnosis and age on children's behaviours

We assessed the interaction effect between diagnosis (ASD vs. TD) and age (5-9 years vs. 10-17 years) on children's behaviours during EAA. Analyses with Kruskal-Wallis test showed a significant interaction effect on the duration of physical contact with horses (H(3)=12.498, p=0.0059), as well as on the frequency of problem behaviours (H(3)=19.588, p=0.0002).

More in particular, post hoc analysis (Dunn's Multiple Comparison Test; four planned pairwise comparisons; level of significance set at 0.05/4=0.013) showed that the lower duration of physical contact with horses shown by ASD children in comparison to TD children (main effect) was due to

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the younger children (p=0.003) while no difference was found between ASD and TD older children (p=0.055).

Likewise, the higher frequency of problem behaviours shown by ASD children in comparison to TD children (main effect) was due to the younger children (p<0.001) while no difference was found between ASD and TD older children (p=0.022).

No age-related differences were found in the frequency of withdrawal/avoidance from the horse and of visual contact towards the horse for which only an effect of diagnosis was observed (H(3)=8.128, p=0.0434 and H(3)=11.970, p=0.0075 respectively, see also paragraph 3.1).

For other behaviours, no significant differences were observed (all $H_s(3)< 3.753$, all $p_s>0.05$).

3.3. Effect of the interaction between diagnosis and EAA experience on children's behaviours

We assessed the interaction effect between diagnosis (ASD vs. TD) and EAA experience (≤ 1 month vs. > 1 month) on children's behaviours during EAA. Analyses with Kruskal-Wallis test showed a significant diagnosis*experience interaction effect on the duration of closeness to the horse (H(3)=18.020, p=0.0004), grooming of the horse (H(3)=17.756, p=0.0005) and physical contact with horses (H(3)=12.887, p=0.0049), as well as on the frequency of visual contact towards the horse (H(3)=12.136, p=0.0069) and problem behaviours (H(3)=22.771, p<0.0001).

More in particular, post hoc analysis (Dunn's Multiple Comparison Test; four planned pairwise comparisons; level of significance set at 0.05/4=0.013) showed an effect of EAA experience on the duration of closeness and grooming only in children with ASD (p<0.001), while no difference was found between TD children with different levels of experience (closeness: p=0.048; grooming: p=0.023; **Figure 2a** and **Figure 2b**).

By contrast, in the case of physical and visual contact with horses, ASD children with more EAA experience were those displaying less occurrence of (or shorter) social behaviours than TD children with the same level of experience (physical: p=0.004; visual: p<0.001; **Figure 2c** and **Figure 2d**). No experience-related differences were found in the frequency of problem behaviours for which only an effect of diagnosis was observed (p=0.508 for ASD children and p=0.748 for TD children); see also paragraph 3.1).

For other behaviours, no experience-related differences were observed (all $H_s(3)< 7.290$, all $p_s>0.05$).

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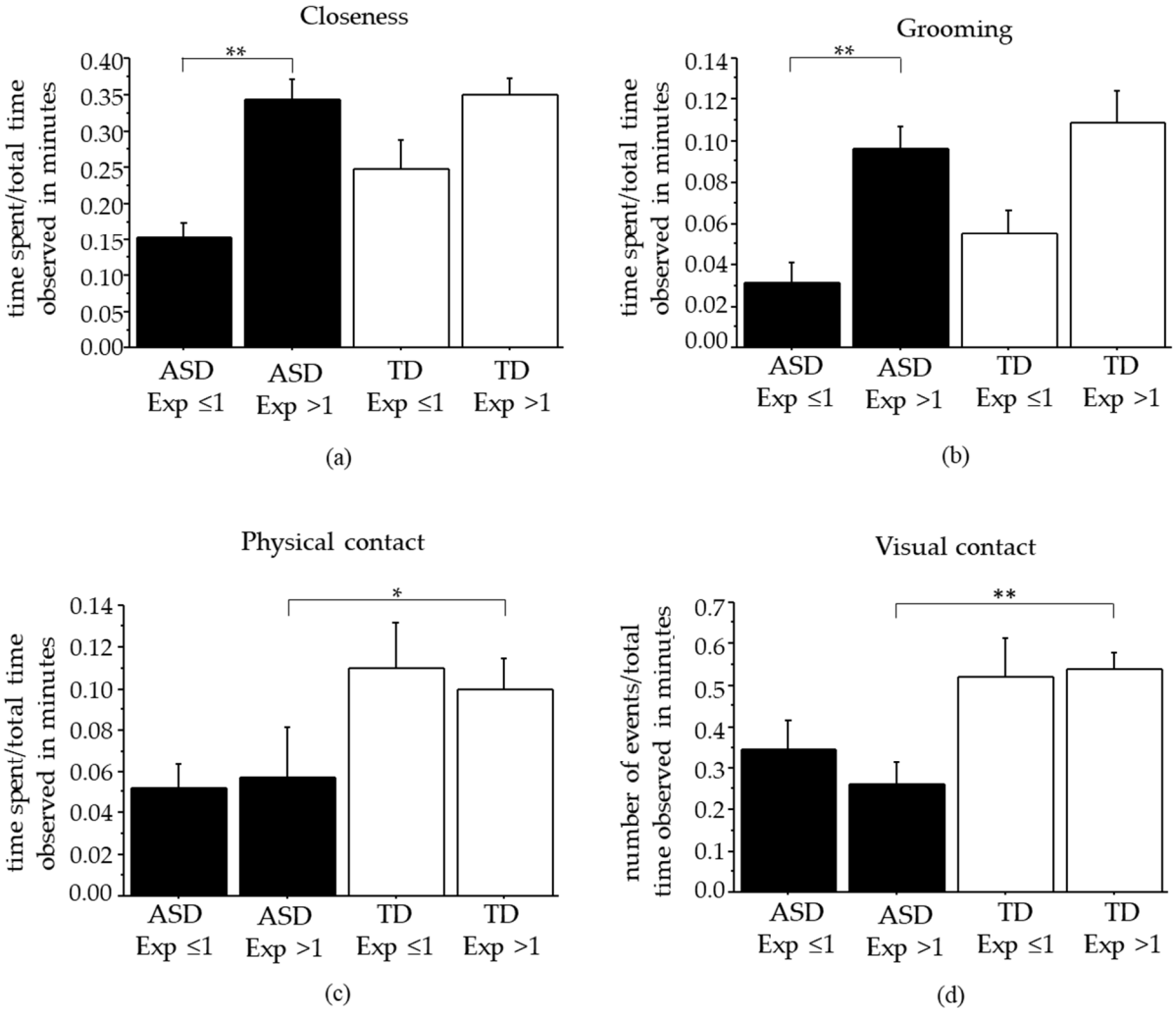

Figure 2. (a) Duration (time spent/total time observed in minutes) of closeness, **(b)** grooming (duration), **(c)** physical contact (duration), **(d)** frequency (number of events/total time observed in minutes) of visual contact in ASD children (black bars) and in TD children (white bars) with EAA experience of ≤1 month or >1 month; *p<0.01**p<0.001.

4. Discussion

This study was specifically aimed at evaluating the behaviour of ASD children, in comparison with typically developing children (TD), during standardized EAA sessions. Overall, data indicate that interaction with a horse is able to elicit social interactions and communicative behaviours in a sex and age-dependent fashion in ASD children. Furthermore, we were able to show that previous experience with EAA can improve interpersonal distance and some interactions with the horse (i.e., grooming), suggesting that positive effects resulting from EAA may build over time.

ASDs are characterized by impairment in social communication and social interaction, as well as repetitive and unusual sensory-motor behaviours [10]. As expected, in our study we found that ASD children showed more withdrawal/avoidance from the horse and more problem behaviours. Likewise, they displayed significantly less visual and physical contact with the horses than children with TD, indicating social and communicative deficits.

Female ASD children showed more withdrawal/avoidance from the horse than female TD, while male ASD children displayed less visual and physical contact with the horse and more problem behaviours than their TD counterparts. ASD is characterized by a higher prevalence of males than females [42] and higher symptomatology in the female gender [43]. These data indicate a clear sex

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difference in the behaviours shown by the two sexes, although data have to be taken with caution as the number of female ASD children recruited in this study was less than half the number of males.

When we considered interaction effects between diagnosis and age on children's behaviours we observed that younger ASD children (5-9 years old) showed a lower duration of physical contact with horses than younger TD children. Consistently, younger ASD children showed more problem behaviours than TD children. These differences tend to decrease with increasing age, probably as a result of an increase in social experience and overall neurobehavioural development.

We grouped ASD children according to their experience with EAA, i.e., less than 1 month of experience or above 1 month of experience. One of the most interesting results of this study is that ASD children with more EAA experience showed a higher duration of closeness to the horse and more grooming than ASD children with less experience. This is probably due to the previously learned skills concerning the approach to the horse and the use of tools for its handling (i.e., grooming).

By contrast, we did not observe an effect of previous EAA experience in the case of physical and visual contact behaviours. It is of interest here that, in both ASD and TD children, experience did not affect these behaviours, which might reflect the fact that they are not a result of experience but involve spontaneous interaction with the animal, which was found constantly lower in ASD children, compared to TD. Overall, these data can be interpreted to indicate that those behaviours that are mediated by the operator handling the sessions, such as closeness and grooming, appear more amenable to be affected by experience, compared to spontaneous interactions, which remain less pronounced in ASD children, no matter how much experience they might have with EAA.

This observation can direct future research efforts on the effect of EAA on other domains of functioning that might be more susceptible to change than social behaviours. A promising avenue of investigation is represented by the potential use of EAA to improve executive functioning in children with ASD. In a previous study we observed that being involved in structured activities requiring the use of tools (such as grooming the horse) is able to improve problem-solving skills in children with ASD after a 6-month EAA program [9]. An increase in attention, ability to focus on tasks and less distractibility following EAA has been also reported and linked to participants high level of engagement and involvement during therapeutic riding sessions [13,15,22]. Although these results are promising, an investigation assessing whether children's improvement after an equine-assisted program generalize to other contexts (such as at home and in the community environments; [44]) is still needed.

5. Conclusions

Results from the current study highlight the importance of exploring children's behaviours during EAA through direct measurements. We developed a specific ethogram to collect information on children's communicative/relational style during EAA sessions, as well as any occurrence of problem behaviours. This approach may allow evaluating child–animal interactions during therapeutic sessions and linking the quality/strength of the child-horse relationship to changes in ASD symptomatology (e.g., social behaviours) obtained by standardized and widely-used scales. Moreover, we were able to capture specific aspects of the social and communicative behaviour of children during their interaction with the horse, getting a much more ethologically-relevant picture of their actions in the session setting.

There is increasing evidence of EAA being a promising complementary intervention for ASD children. Being able to stimulate the physical, social and cognitive domains [2,11,18], and being carried out outdoors and in green spaces [45], activities with horses have a great potential to be well integrated within the overall rehabilitation plan of children with ASD. In the future, long-term assessments and a combination of qualitative and quantitative tools (parent questionnaires, standardized tests, video coding) should be used to evaluate their overall effectiveness, allowing EAA to become an evidence-based practice for ASD.

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Supplementary Materials: Table S1: Description of horses involved in the current study.

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