POINTS OF VIEW

Effects of equine interaction on EEG asymmetry in children with autism spectrum disorder: a pilot study

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Objects: This purpose of this study was to determine the relationship between resting frontal electroencephalogram (EEG) brain activity and the interaction with the horse in young children with autism spectrum disorder (ASD).

Methods: Resting frontal EEG alpha asymmetry was recorded from two young children with ASD and two young typical children matched for age and gender during a baseline and an interaction conditions with the horse.

Results: Young children with ASD exhibited higher left frontal dominance during the baseline condition. While grooming the horse, young children with ASD exhibited the right frontal dominance.

Conclusions: This change may be attributed to the interaction with the horse. It changed the attentional focus of young children with ASD. In addition, the calmness of the horse might be transformed to young children with ASD. Future studies with larger sample sizes and behavioural measures of social functioning may help explain the horse related benefits in children with ASD.

Introduction

Resting frontal EEG alpha asymmetry and social functioning in children with ASD

Autism is a developmental disorder that affects the development of the brain, particularly in the areas of communication and social interaction. A latest report released from CDC noted this disorder now affect one in eighty-eight children. This number is increased 78 percent from 2002 and 23 percent from 2006. Thus, there is a need to understand the casual factors behind this disorder. Recent studies have suggested that electroencephalogram (EEG) resting frontal alpha (8–12 Hz) asymmetry is one of the potential neural endophenotypes and may be associated with social dysfunction in children with autism spectrum disorder (ASD) (Wang *et al.*, 2013). For example, Sutton *et al.* (2004) examined the associations between one-min resting frontal EEG alpha symmetry and social functioning in children and adolescents with ASD. They indicated, in typical peers, they exhibited a greater right frontal activity, if they showed greater social and general anxiety. However, in the autistic group, they exhibited a greater left frontal activity, if they showed greater social anxiety, general anxiety and social stress, and less satisfaction with interpersonal relations. Further, this opposite pattern was also confirmed by Burnette *et al.* (2011). They indicated that greater left frontal activity was associated with high levels of self-reported outward expressions of anger as well as symptoms of obsessive compulsive disorder in higher functioning children with ASD. Based on both studies, it seems that resting frontal EEG alpha asymmetry may be a valid measure to define individual differences in children with ASD.

DOI 10.1179/2047387714Y.0000000044

Resting EEG frontal alpha asymmetry model

Resting EEG frontal alpha asymmetry has been applied to understand human affect and social functioning in typical populations. Davidson and his colleagues (Davidson, 1984; Wheeler, Davidson and Tomarken, 1993) recorded in typical infants' EEG following the presentation of the film clips that elicited positive or negative affect and led to a model that greater activity of the left hemisphere relative to right occurs during positive affect and were associated with an approach system and positive feelings. A greater activation of the right hemisphere relative to left was associated with an avoidance and withdrawal system and negative feelings. Following Davidson's model, Schmidt (1999) further demonstrated shyness to be associated with greater right frontal brain activity, whereas sociability was associated with greater left frontal brain activity in college students. Most recently, Tuscan and colleagues (2013) applied functional near-infrared spectroscopy to explore the effects of social anxiety on resting EEG frontal alpha asymmetry in undergraduate students and found high anxiety group showed greater right frontal activity than low anxiety group. Thus, these studies suggest that the frontal areas involvement is asymmetric and it may be an objective reflection of complex cortical and sub-cortical systems associated with individual difference in affect and social functioning.

Equine therapy and social functioning in children with ASD

Furthermore, animal-assisted therapy (e.g. horse) has been applied to improve social and emotional functioning through the interaction with the animals (Bizud *et al.*, 2003; Kaiser *et al.*, 2004). As for individuals with ASD, Bass *et al.* (2009) conducted a 12 week horseback riding program and found school-aged children with ASD exhibited sensory seeking, social motivation, and less inattention and irritability after the intervention. Moreover, Gabriels *et al.* (2012) found children with ASD improved social skills, measured by Vineland Adaptive Behavioral Scales (VABS-II, Sparrow *et al.*, 2005), after a 10 week horseback riding program. Both studies demonstrated that this horse-human interactive activity has a potential therapeutic effect on social functioning in children with ASD. The observed changes in social functioning may be attributed to the interaction with horse that might facilitate positive affect and approached mindsets in children with ASD. However, these finding mainly came from subjective rating instead of objective information. To our knowledge, there is no objective measure, such as resting EEG frontal brain activity, to provide the mechanism to support these behavioral changes.

Current study

Given previous EEG studies with infants and children and the equine therapy study effects, the purpose of this study was to investigate the influence of a horse on the resting EEG frontal asymmetry in young children with ASD. Thus, one might predict young children with ASD will exhibit higher left frontal brain activity because of their social dysfunction. In addition, a social influence of the horse on young children with ASD will lead to a decrease in left frontal brain activity.

Method

Participants

Two young children with ASD, determined by Modified Checklist for Autism in Toddlers (M-CHAT), and two age and gender matched typical children between the ages of 28 and 36 months (without physical disabilities) volunteered to participate in the current study (refer to Table 1 for participant characteristics). M-CHAT is a 23-item checklist that relies on parents or guardians' report of a child's skills and behaviours. There are 6 critical items that were found to have the greatest discriminability between children with and without ASD (Robins *et al.*, 2001). If child failed (e.g. a 'no' answer) in 2 or more critical items, he/she should be evaluated

TABLE 1

PARTICIPANT CHARACTERISTICS

Participant	Age/months	Gender	Diagnosis
XS-1	34	M	ASD
SA-2	36	M	None
JW-3	30	F	ASD
TW-4	28	F	None

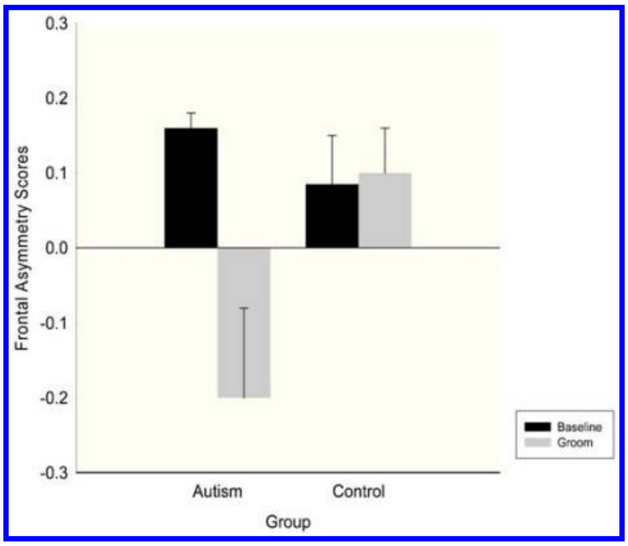

FIGURE 1 Frontal asymmetry scores in the baseline and groom conditions between ASD and Control Group.

for a disorder on the ASD spectrum. All ASD participants were recruited from Hunkapi Horse Program in Phoenix, Arizona and matched with typical children for age and gender. Before the experiment started, parents/guardians were informed and provided written voluntary consent forms. All protocols were approved by the Human Subjects Institutional Review Board and the Institutional Animal Care and Use Committee of Arizona State University.

EEG data collection and analysis

EEG data were collected using the International 10–20 system (Jasper, 1958) for the participant to assess brain activity. Silver-silver chloride electrodes were attached to the participant's head in order to measure activity in the anterior right and left hemispheres of the brain (F3, F4). Linked mastoids were used as reference electrodes. A ground electrode was placed at the CZ location. A 32-channel NeuroScan NuAmps EEG (Compumedics, Charlotte, NC, USA), with SCAN 4·3 software, was used to acquire and analyze the EEG data. Impedance was kept below 5k ohms for the EEG electrodes. The sampling rate for all data was 1000 Hz. The high- and low-frequency filters were 0·01 and 100 Hz and the signals were amplified by a factor of 50 000.

One-min frontal brain activity was collected to represent social responsiveness during baseline and the interaction with the horse. Eye movements were recorded to remove artifacts. After rejecting all artifacts manually, a fast fourier transform (FFT) was used to obtain power spectrum data (in μV^2). Total power within the alpha band (8–12 Hz) was obtained and all values were log transformed to normalize the data (in $\mu V^2/Hz$). The EEG asymmetry scores were computed by subtracting the log-transformed left power density from the log-transformed right power density (log F4–log F3). Positive scores reflect greater left brain alpha activity relative to right, whereas negative scores reflect greater right brain alpha activity relative to left.

Procedure

Upon arriving, Parents/guardians were instructed to fill out the Modified Checklist for Autism. Following this, two conditions of brain activity of the participants were collected in the same order, for one minute, for each condition. First, participants were in a separate location than the horse. They sat and played with a toy they preferred while EEG data was recorded. Then, participants were requested to groom the horse. The participant groomed the horse with a brush, again from the position between the horse's head and shoulders.

Results

Resting EEG frontal alpha asymmetry averaged for two children with ASD and averaged for the two typical children are graphed in Fig. 1. As can be seen in Fig. 1, the mean frontal asymmetry scores reveal that typical young children exhibited a positive asymmetry score (i.e. greater left frontal alpha activity) during the baseline and grooming with the horse. As for young children with ASD, they had a higher positive asymmetry scores than typical young children during the baseline (i.e. greater left frontal alpha activity). However, they exhibited a negative asymmetry scores during grooming with the horse (i.e., greater right frontal alpha activity). This study demonstrated that the equine-assisted activity resulted in higher left frontal asymmetry in typical children and the change from left frontal asymmetry to right frontal asymmetry in young children with ASD.

Discussion

This study is innovative in that it examined brain activation in young children with ASD during interaction with a horse. To our knowledge, this is the first study to examine the effect of equine-assisted activity on frontal brain activation in young children with ASD. First, consistent with previous EEG study, young children with ASD exhibited a higher positive asymmetry score (i.e. greater left brain activity) during baseline condition because parental report in M-CHAT showed young children with ASD had rare behaviour in social interest, social play and prone to imperative pointing (pointing to ask for something).

Further, consistent with our hypothesis, this study demonstrated a change in brain activation between the left and right hemispheres in young children with ASD compared to typical children during the interaction with the horse. Based on previous EEG and therapeutic studies (Sutton *et al.*, 2004; Burnette *et al.*, 2011), this change from left brain activity to right in the frontal lobes may be an indication of enhanced social behaviour through the interaction with the horse. Most importantly, if this single bout effect can be performed regularly, the additive effect could result in more pronounced benefits for children with ASD.

One of the possible explanations for the change in frontal brain activity is diversion. In the current study, young children with ASD had to learn the sequencing while grooming the horse. Their focus on was on the horse and no longer on themselves. This environment provided an opportunity for safe social interaction with the horse. People are often more difficult to interact with than an animal. In addition, the horse has the ability to sense certain weaknesses in children with ASD and responds by remaining calm (Stevens, 2007). During experiment, it is possible that the calmness from the horse was transferred to the child with ASD during grooming.

As for young typical children, they exhibited higher positive asymmetry score (i.e. greater left brain activity) compared to their baseline condition. Based on asymmetry model, in typical population, this increase may result from that they performed a social approaching behaviour while their grooming with the horse.

Although resting EEG frontal asymmetry has been applied in children with ASD; however, the small sample size was a limitation in the current study. Future study should consider more participants and different conditions with the horse (e.g. riding with horse). Furthermore, a longer period of interaction with the horse could also include measures of social behaviour to determine if the horse influences social interaction as previously shown and whether resting EEG frontal measures may be a mechanism to explain possible differences in social functioning. However, the result of this study provides a new form of observation and indicated change in resting EEG frontal asymmetry in children with ASD.

Disclaimer statements

Contributors: We appreciate Dr Crews for helping us with participant recruitment. Thank you to Stephanie Mundt who was the student who helped with data collection.

Funding: This research was supported by Barrett, The Honor College at Arizona State University.

Conflicts of interest: The authors have no conflicts of interest to declare in reference to this work.

Ethics approval: All protocols were approved by the Human Subjects Institutional Review Board and the Institutional Animal Care and Use Committee of Arizona State University.

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