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NEURAL CORRELATES OF SELF-PERCEPTION IN INDIVIDUALS WHO VARY IN SOCIAL ENGAGEMENT

A THESIS APPROVED FOR THE
DEPARTMENT OF PSYCHOLOGY

BY

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Abstract

Electroencephalography (EEG) studies indicate a reduced or absent self-preference effect for faces in individuals diagnosed with autism spectrum disorder (ASD). The current study extends these findings to individuals below the diagnostic cut-off for ASD who differ in social engagement and extends the modality to auditory stimuli. Participants (n=908) were classified as either high or low in social engagement, but within the sub-clinical range, using the Autism-Spectrum Quotient and the Broad Autism Phenotype Questionnaire, then during dense array EEG a subset of participants (n=21) were presented with images of faces or names, read auditorily, in three categories: themselves (24 trials), a close "other" (24 trials), and a stranger (72 trials). A marginally significant interaction between peak and social engagement was observed on amplitude when viewing faces. There was a significant effect of condition on P300 for component 1; higher amplitudes were recorded in response to viewing images of the close other. A significant interaction between condition and social engagement was observed for latency. A main effect of condition on amplitude was noted when hearing names. Additionally, a main effect of condition on latency for names was observed. For P300 latency in response to names, a main effect of condition was observed, suggesting the self-preference effect occurs in response to auditory stimuli.

Keywords: Autism, EEG, social engagement, communication, self-preference effect, AQ, BAPQ

Chapter 1: Introduction

ASD has a prevalence of 1 in 68 individuals in the US, making it one of the most common neurodevelopmental disorders. Its commonly reported symptoms include social and communicative impairment, repetitive behavior, and restricted interests (APA, 2013). A wealth of research has focused on the social symptoms, but the need still exists to understand social/cognitive deficits as related to the self. While many studies have reported deficits in processing familiar vs unfamiliar faces in ASD (Cygan, Tacikowski, Ostaszewski, Chojnicka, & Nowicka, 2014), few have focused on the neural correlates of recognizing and processing the self beyond a simple differentiation based on familiarity, despite the wealth of behavioral literature on theory of mind deficits in ASD (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997; Baron-Cohen, Leslie, & Frith, 1985; Happé, 1994; Ozonoff, Pennington, & Rogers, 1991). Recent literature has shed light on a different neural pattern that emerges for those with autism in response to the self as opposed to when viewing a close other such as a friend or loved one (Cygan, Tacikowski, Ostaszewski, Chojnicka, & Nowicka, 2014). This study provided evidence for a reduced or absent self-preference effect for individuals with ASD. Through analysis of P100, N170, and P300, data indicated that for the control group, the self-preference effect was clearly demonstrated: higher P300 amplitude was observed in response to presentation of the own face and own name on a computer screen. However, for the ASD group, presentation of both the own face and close other was associated with enhanced P300. These findings illustrated that for individuals with ASD, similar attention was allocated for any familiar face or name, rather than for the self only as in the typically developed group. It is important to

understand this impairment in differentiating the self and close others; honing in on how individuals and relationships are processed is imperative in creating the best and most viable treatment options for individuals with ASD. Through exploration of this issue and application of the knowledge gained, therapists, doctors, and practitioners can begin to attempt to address the restrictive social deficits that alienate individuals with ASD from many aspects of society.

Although few studies concerning visual perception of the self have been conducted, many auditory studies have been completed. One fMRI study focused on the brain areas activated when an individual hears one's own name in non-autistic participants (Carmody & Lewis, 2006). Findings indicated greater left hemisphere activation in response to hearing one's own name in the middle frontal cortex, superior temporal cortex, and cuneus. Another fMRI study investigated responses to viewing images of faces of the self and others by typically developed children and children with autism (Uddin et al., 2008). In this study, the images shown were digitally morphed versions of the individual's own face combined with different percentages of another face of the same gender. Children with ASD only activated the prefrontal/premotor system when viewing images that were mostly the own face, as opposed to typically developed children, who recruited this system when viewing all faces.

While few studies highlight self-perception in children with autism, basic sensory studies of children with autism using both EEG and magnetoencephalography (MEG) generally show atypical ERP response at early latencies. These were observed in P100, N100, P200, and P300 when children were exposed to a simple tone or flash of light (Martineau, Garreau, Barthelemy, & Lelord, 1984). This indicates impairment in

visual sensory processing, which is key to adequately responding to the social environment and self-referential stimuli. N1c, used to measure auditory temporal responses, was found to show smaller amplitude and longer latency in children with autism than controls (Bruneau, Bonnet-Brilhault, Gomot, Adrien, & Barthélémy, 2003). This further implies that children with autism have more trouble processing auditory stimuli. Another auditory study compared linguistic impairment between children with autism and those with specific language impairment. This MEG study showed the right hemisphere M50 latency as a useful indicator of this impairment in both types of children with language impairment, physiologically providing evidence that children with autism have basic sensory deficits associated with difficulty in understanding language, a crucial component of the social world (Cardy, Flagg, Roberts, & Roberts, 2008).

Autism is a spectrum of disorders, with some manifestations having more symptoms that affect daily life than others. Social function in society exists along a continuum, with clinically relevant features of autism populating the more extreme low end of that spectrum. Because variability in social function may be continuous, without a clear demarcation at the diagnostic threshold, it is important to study self-preference in people on both the high and low end of the complete spectrum. In order to do this, it is also important to understand how people who do not meet diagnostic criteria for ASD but exhibit variable social preferences function in the social and individual world. In this study, people who do not meet diagnostic criteria for ASD were placed into both high- and low-social groups, allowing for investigation of neural activity correlated with the process of perceiving the self and others as it relates to a continuum.

The ERP Method

The event related potentials (ERP) method was selected for this experiment due to its ability to highlight neural mechanisms underlying sensory and cognitive processing that may not always be apparent when studying overt behavior. Using this method has allowed researchers to look at sources of the core symptomatic deficits in autism by allowing focus on fundamental processing impairments and linking these to those social deficits that typically define the disorder (Jeste & Nelson, 2009). ERPs show changes in electrical activity across the scalp surface in response to an event or stimulus as part of the ongoing EEG recording. The components studied are labeled based on certain signal characteristics. Each is labeled with a "P" or "N," representing positive or negative voltage in the area of peak activity, and a number representing either the latency or the order in the train of components. For example, P300 or P3 is a positive component that occurs about 300 ms after stimulus onset and is the third major positive component. The early components reflect basic-level sensory processing, while the later components reflect cognitive and perceptual stimulus processing.

For auditory stimuli, N100 occurs between 80 ms and 120 ms after stimulus presentation and is thought to be generated in the primary auditory cortex with additional activation in occipito-parietal cortex, occipito-temporal cortex, frontal cortex, association auditory cortex, planum temporale, superior temporal gyrus, and Heschl's gyrus (Zouridakis, Simos, & Papanicolaou, 1998; Clark, Fan, & Hillyard, 1994; Godey, Schwartz, de Graaf, Chauvel, & Liégeois-Chauvel, 2001; Näätänen & Picton, 1987). P100 is a very reliable peak that appears as a large positive wave, occurring at about 100 ms after stimulus onset. It is known to originate in the extrastriate cortex for visual

stimuli and is modulated by attention (Mangun et al., 1993). For auditory stimuli, the signal originates in the auditory cortex; it is collected at electrodes over fronto-medial sensors due to the orientation of the auditory cortex. N170 is the earliest, most prominent, widely-studied visual ERP component that elicits a larger negative-going ERP in response to faces rather than objects (Eimer, 2010). It occurs between 130 ms and 200 ms post-stimulus (Rossion & Jacques, 2008). The source for N170 is at the inferior-temporal gyri and fusiform face area, and it is collected at electrodes in the occipito-temporal region. Evidence indicates that P200, peaking between 175 ms and 200 ms, may reflect neural processing when a sensory input is compared with memories, expectations, or internal representations (Evans & Federmeier, 2007). Known sources include the secondary auditory and visual cortex (Ross & Tremblay, 2009; Omoto et al., 2010). It is collected at electrodes in the centro-frontal and parieto-occipital regions for auditory and visual stimuli, respectively. P300 is elicited when cortical processing of a task-related event occurs; it is attention-dependent and therefore reflects higher-level cognitive processing of a stimulus (Jeste & Nelson, 2009). This component, occurring between 250 and 500 ms after stimulus presentation, generates during the processing of stimulus information in context of task (Polich, 2007). P300 sources include the inferior parietal lobe, temporo-parietal junction, superior temporal gyrus, dorsolateral prefrontal cortex, insula, anterior cingulate cortex, and the supplementary motor cortex; it is collected at electrodes over the parietal region (Mulert et al., 2004). Each of these components has been implicated in visual and auditory processing deficits in ASD (REFs), but less is known about how these components vary systematically with ASD-like features in the general population. In order to adequately

capture and understand social processing variability as it relates to the autism spectrum continuum, it is necessary to investigate activity at these key component locations.

In this study, we aim to identify the peak latencies and amplitudes at each component of interest for individuals both high and low in social engagement, collected while viewing images or hearing the names of the self, close other, and strangers. We hypothesize that, following the patterns in previous research, individuals high in social engagement will exhibit higher amplitudes at task-relevant processing peaks in response to the self than will those low in social engagement. The hypothesized peak differences are expected to occur at N170, P2, and P3.

Chapter 2: Method

Participants

Twenty-one adults (see Table 1 for demographics by group) completed the EEG portion of the study at the University of Oklahoma. Each was prescreened using the Autism-Spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) and the Broad Autism Phenotype Questionnaire (BAPQ; Hurley, Losh, Parlier, Reznick, & Piven, 2007). Participants with a score below 1.90 on the BAPQ aloof subscale and below 2 on the AQ social skills subscore were selected as individuals high in social engagement. Participants with a score above 3.25 on the BAPQ aloof subscale and 4 or more on the AQ social skills subscore were selected as low in social engagement. This range was decided using the parameters for typical and atypical individuals based upon the published cutoff values (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001). Participants were prescreened via questionnaire to ensure that no developmental delays, disabilities, or psychiatric disorders were present, including ASD. Minimum sample size per group was calculated by choosing the mid-level effect size (0.6) from the previously cited research (Cygan, Tacikowski, Ostaszewski, Chojnicka, & Nowicka, 2014), power of 0.95, and type I error rate of 0.05. Using g*power software, the minimum sample size per group was indicated to be 12 individuals (Faul, Erdfelder, Lang, & Buchner, 2007).

Procedure

To discover individuals with no clinical diagnosis who varied socially, an anonymous online survey was created containing the AQ, BAPQ, demographic, and

health-related questions. The survey was distributed online to introductory psychology students in exchange for course credit, e-mailed as a link to the Norman campus student body, and advertised online to recruit non-students as well. All survey participants provided written informed consent prior to beginning the survey. Participants were given the option to provide an email address to be contacted at a later date for further inclusion in the EEG study. If inclusion criteria were met and no history of mental illness was reported, an individual was sent a personal e-mail inviting them back to complete the EEG portion of the experiment. Interested individuals were given further detail and asked to provide a face-forward unobstructed photograph of both the self and someone with whom they feel a close emotional bond, along with first and last name of each.

Qualifying participants were brought to a light, sound and electrically-shielded room to complete the EEG portion of the experiment. Participants provided a close-up, face-forward photograph of a close friend or family member and the self in advance, along with names for the same two categories; these were recorded or uploaded on-site into the program and removed once the participant completed his or her EEG session.

During the EEG portion of the experiment, participants were outfitted with a 128-channel acquisition net (Electrical Geodesics, Inc.) with sensors placed according to an approximated 10-20 system while sitting in front of a computer screen. EEG was sampled at 500 Hz, amplified 10,000x, digitized, bandpass filtered from .1-100 Hz and referenced to Cz. The experiment was compiled using Presentation® software to present the stimuli and measure responses (Neurobehavioral Systems, Albany, CA, USA). For the visual portion, participants viewed photos of the self, a close other, and a

stranger in random order presented on a computer screen for 500 ms, with an interstimulus interval varying randomly between 1000 ms and 1500 ms. For the audio portion, participants listened to an audio recording of the names of the self, close other, and stranger, presented via headphones for approximately 2000 ms, depending on length of the name, with an interstimulus interval varying randomly between 1000 ms and 1500 ms. In response to each stimulus, the participant was simply asked to press a button using the index finger of the right hand as fast as he or she was capable once the image or sound appeared. Responses were considered correct if the button was pressed between 150-1000 ms after stimulus onset.

Stimuli/Apparatus

Faces were presented visually on a computer screen, and names presented via Etymotic insert earphones in two separate runs. Run order was randomly counterbalanced, with half beginning with the auditory portion and the other half beginning with the visual portion.

During the face detection run, participants viewed color images of faces from three categories against a black background: self, close other, or stranger. Each face image consisted of a cutout circle so that only face, ears, and hair were visible surrounded by a white background, creating a rectangle measuring approximately 2.5" x 3.5" (retaining dimensions) that appeared on a black background. Luminance and size matched stimuli for strangers were provided by an online database (Bainbridge, Isola, & Oliva, 2013). Stranger faces were selected using stratified sampling of the ethnic composition of the University of Oklahoma Norman campus. Each image provided by

participants was luminance-matched and size-adjusted to match the stranger faces using Adobe Photoshop software. Visual stimuli were displayed locked to screen refresh rate on a 60 Hz LCD color monitor. Once detected, the participant was asked to press the space bar on a standard keyboard. Faces from each category were presented in random order at 100 cm viewing distance for a total of 72 stranger trials, 24 close-other trials, and 24 self trials.

The auditory stimuli were recorded and tone-matched using Audacity software and onset matched via Matlab v. r2015a (The Mathworks, Natick MA) to prevent individual differences. Names were read using NaturalReader 14.0 software (NaturalSoft Ltd., Vancouver BC Canada) using the voice 'Lauren' at the speed 0. The participants heard names read through headphones at ~70 db and were asked to respond by pressing the space bar once the name was heard. Participants were asked to remain face-forward and looking at a fixation cross on the screen for the duration of the audio run. Names from each category were presented in random order for a total of 72 stranger trials, 24 close-other trials, and 24 self trials. Including setup, assessment, equipment placement, and experimental protocol, each session lasted between 1 and 2 hours.

Data Analysis

Correct response times (RTs) were analyzed using an analysis of variance (ANOVA) using the following factors: group and condition. Potential covariates (i.e. age and gender) were documented and explored in this analysis.

EEG sessions were conducted in an EMF/RF shielded, sound-attenuated and light-attenuated chamber. For EEG data, a high-density 128-channel EEG system (EGI) was used to collect data at the five components of interest: P100, P200, N100, N170, and P300. The highest amplitude of ERP within each above-mentioned time range and characteristic topography was visually selected for comparison. For visual P100, the expected time range is 90ms – 100 ms after stimulus onset. For visual N1, the expected time range is 90 ms – 100 ms after stimulus onset. For auditory N1, the expected time range is 80 ms – 120 ms after the onset of the stimulus. For visual N170 and auditory N2, the peak amplitude is expected to occur between 130 ms – 200 ms and 225 ms to 250 ms, respectively. The peak amplitude for P2 is expected to occur between 175 ms and 250 ms, and for P3 the peak amplitude is expected between 250 ms and 500 ms post-stimulus onset.

Raw EEG data were visually inspected to identify bad channels, which were then interpolated using spherical spline interpolation (BESA 6.1, MEGIS Software, Grafelfing, Germany). No more than 5% of channels were interpolated for any participant. Biological artifacts, such as heart rate and eye movements, were removed using Independent Components Analysis (EEGLAB 13.5.4b). Digital bandpass filters were applied from 0.5 – 55 Hz (6 db and 12 db per octave rolloff, respectively) with a zero-phase filter. Data were then epoched from 500 ms before stimulus onset to 750 ms after stimulus onset for each condition. At least 90% of trials were accepted for all included participants.

In order to adequately examine spatial topography of ERPs over time, principal components analysis (PCA) with Varimax rotation was conducted on grand average

data for each group with temporally concatenated conditions using BESA 6.1 (MEGIS Software, Grafelfing, Germany). Concatenating conditions creates a single PCA solution across conditions to which allows for direct comparison of spatial components between conditions while still allowing for contribution of unique variance from each condition to the PCA solution. For each task, number of components retained was determined by the elbow method for the scree plot. Condition averages within-task for each individual were then weighted by the component weights and averaged over sensors, producing a single "virtual sensor" for each participant, component, and condition, spatially weighted toward sensors most strongly representative of that particular spatial component topography. This method allows the data to be reduced from 128 sensors to one, greatly reducing the need for multiple comparisons.

Repeated measures mixed-model ANOVA was performed on latencies and amplitudes for each component and each task using the following factors: group (between-subject, 2 levels), peak (within-subject, 2 levels for auditory, 3 levels for visual), and condition (within-subject, at the levels of self, close-other, or stranger). Since the P300 was not observed in the stranger condition, a separate group by condition repeated measures ANOVA was performed for P300 amplitude and latency.

Chapter 3: Results

Behavioral

Behavioral data were analyzed for correct responses of each subject; responses were considered correct if the space bar was pressed within 150-1000 ms after onset of the stimulus. Response times were analyzed using an ANOVA with the factors group and condition. No significant behavioral differences in reaction time were recorded for faces or names by group or condition.

Electrophysiological Data

PCA results revealed two retained components for each task. For faces the components were an occipito-parietal component accounting for 67.9 % of the variance and a centro-parietal component accounting for 22.8 % of the variance (see Figures 1 and 2 for component topographies). For names the components were a parietal component accounting for 60.4 % of the variance and a fronto-central component accounting for 27.8 % of the variance.

Faces

Mauchly's test revealed that for peak, the data violated the assumption of sphericity ($X^2(2) = 8.01$, $p = .018$), so the Greenhouse-Geisser estimates are reported for all significant results concerning peak ($\varepsilon = .727$). Repeated measures ANOVA revealed an expected main effect of peak on amplitude at component 1 F (1.454, 26.169) = 40.122, $p = .000$, partial eta squared = .690. Further, a marginally significant interaction between peak and social engagement on amplitude was observed F (2,

26.169 = 2.814, p = .092, partial eta squared = .135. Individuals high in social engagement (M = -2.344) showed stronger mean amplitudes for N1 than individuals low in social engagement (M = -1.541). However, an independent samples t-test revealed that these differences were not significant by condition at the .05 level. For N170, individuals low in social engagement (M = -4.532) had stronger mean amplitudes than those high in social engagement (M = -2.317). However, t-tests revealed that these differences were not significant by condition at the .05 level. Finally, for P2, individuals low in social engagement (M = 2.182) exhibited no significant difference in mean amplitudes than those high in social engagement (M = 1.999). For P300 amplitude at component 1, a significant main effect of condition was observed F (1, 18) = 9.299, p = .007, partial eta squared = .341. For individuals both high and low in social engagement, stronger amplitudes were recorded in response to the close other than to the self. No effect of social engagement on P300 amplitude was observed for component 1.

Mauchly's test of sphericity revealed a violation of the assumption for both peak ($X^2(2) = 10.953$, p = .004), and condition ($X^2(2) = 11.223$, p = .004), so the Greenhouse-Geisser estimates were retained (ε = .678, .674; respectively). Further analysis revealed the expected significant effect of peak for component 2 amplitude F (1.356, 24.408) = 16.596, p = .000, partial eta squared = .480. Expected differences in amplitude were observed at each of the three components N1, N170, and P2. No significant differences in P3 amplitude were observed for component 2.

For the test of effects on latency, Mauchly's test revealed a violation of the assumption of sphericity for condition ($X^2(2) = 15.343$, p = .000), ε = .627) and

condition x peak ($X^2(2) = 25.861$, $p = .002$), $\varepsilon = .557$), so Greenhouse-Geisser estimates are reported. A significant main effect of condition on latency was observed F (1.254, 22.578) = 73.255, $p = .000$, partial eta squared = .803. Importantly, a significant interaction between condition and social engagement on latency was observed F (2, 36) = 6.515, $p = .004$, partial eta squared = .266. For individuals low in social engagement, the longest overall latency across peaks was observed while viewing photos of a close other ($M = 209$), followed by photos of the self ($M = 177.4$), and strangers ($M = 100.4$). For individuals high in social engagement, the longest latency was observed while viewing photos of the self ($M = 237$), followed by the close other ($M = 203.2$) and strangers ($M = 96.133$). No significant main effect or interaction of condition or social engagement occurred for P300 latency.

Names

For component 1, the expected main effect of peak on amplitude was observed for N2 and P2 F (1, 14) = 20.471, $p = .000$. Additionally, no effect of social engagement or condition was observed for P300 amplitude at component 1.

For component 2, the expected main effect of peak on amplitude was observed F (1, 15) = 21.474, $p = .000$, partial eta squared = .589 for N2 and P2. Further, a significant main effect of condition on amplitude was observed F (2, 28.991) = 4.219, $p = .026$, partial eta squared = .220. The pairwise comparison between the stranger ($M = .571$) and self ($M = -.689$) condition was significant, $p = .007$. No other comparisons based on condition were significant, although the pairwise comparison between other

and self approached significance. There were no significant differences in P3 amplitude for component 2 based on social engagement or condition.

Latency effects were observed for N2 and P2. The expected main effect of peak on latency was observed F (1, 15) = 36.683, p = .000, partial eta squared = .710. For the test of effects of condition on latency, Mauchly's test revealed the sphericity assumption had been violated(X^2(2) = 13.382, p = .001), ε = .698), so the Greenhouse-Geisser estimate was retained. A significant main effect of condition on latency was recorded F (1.238, 18.570) = 34.710, p = .000, partial eta squared = .698. Additionally, a significant interaction between peak and condition on latency was observed F (2, 30) = 32.754, p = .000, partial eta squared = .686. For N2, longer latency was observed when hearing one's own name (M = 265.667) than when hearing the name of a close other (M = 192.139) or stranger (M = 193.833). For P2, the longest latency occurred in response to the self (M = 263.819), followed by the close other (M = 262.389) and stranger (M = 193.708).

A significant main effect on P300 latency of condition was noted F (1, 15) = 4.911, p = .043, partial eta squared = .247. Shorter latency was observed in response to one's own name (M = 387.319) than to the name of a close other (M = 411.431). Finally, a marginally significant interaction of social engagement and condition on latency for auditory P300 was observed F (1, 15) = 4.047, p = .063, partial eta squared = .212. For individuals low in social engagement, the mean latencies for hearing the name of a close other (M = 421.111) and self (M = 418.669) were much more similar than for those high in social engagement; for those individuals, the mean latency in response to the self (M = 355.750) was much lower than when responding to the close

other (M = 401.750). While the difference in P300 latency for those low in social engagement was not significant, P300 latency for high SE was significantly shorter in response to the self, $t(7) = .048$.

Chapter 4: Discussion

The goal in the current study was to investigate neural activity related to perception of faces and names in individuals who vary in social engagement. The names and faces used differed by the level of emotional significance to each individual. We were interested in determining whether the self-preference effect would be reduced or absent in those with no clinical psychological diagnosis but who nonetheless showed lower social activity and skill. Further, we attempted to extend previous research by exploring whether the observed visual effects would be replicated and extended to auditory stimuli.

For visual N100, marginally higher amplitudes were noted for individuals high in social engagement than for those low in social engagement. Luo and colleagues (2010) demonstrated that visual N100 is modulated by attentional resources; this implies that individuals high in social engagement may be recruiting more attentional resources when viewing faces.

In previous research, N170 was found not to be sensitive to the identity of the face, but rather to physical features allowing the brain to discern face vs. non-face stimuli (Ghuman et al., 2014). In this study, we too found no significant differences based on the identity of the face being viewed. However, N170 amplitude was marginally stronger for individuals low in social engagement than it was for people high in social engagement. Previous research demonstrated enhanced N170 for individuals high in social anxiety (Mühlberger et al., 2009). Perhaps this sheds light on the current finding – individuals lower in social engagement may be experiencing enhanced N170 due to differences in social desire and comfort.

P200 is thought to reflect an attention-modulated aspect of higher-order perceptual processing. For stimuli that are highly categorizable, P200 typically occurs earlier than for other stimuli types (Pernet et al., 2003). This earlier latency is believed to reflect ability to access memory and storage. In this study, visual P2 amplitude was not significantly stronger for individuals low in social engagement than it was for individuals high in social engagement. Since all presented stimuli could be easily categorized as belonging to their respective categories, this lack of differences makes sense. Neither group showed any deficit in ability to access memory and storage.

The significant interaction on visual N100, N170, and P2 latency between condition and social engagement is worth further exploration. For individuals low in social engagement, longest latency was observed in response to the close other, followed by the self and stranger, respectively. For those high in social engagement, however, the longest latency was reported in response to the self, followed by the close other and stranger, respectively. For both social engagement types, the shortest latency was observed for strangers. However, during processing of individuals with emotional relevance we see an interesting difference between the two groups. The increased latency suggests preferential attention allocation to the stimulus in that category; for those high in social engagement, this was the self, while for those low in social engagement, this was the close other.

Perhaps this latency difference relates to the degree to which self-representation is shared with representations of others. Individuals low in social engagement failed to show the same self-preference effect as those high in social engagement; this suggests that individuals low in social engagement may show more shared representations

between self and others, an effect that has been noted in individuals with ASD (Cygan et al., 2014). Prior research indicated that non-clinical individuals do, in fact, share some aspects of their representations of the self with those of close others (Aron et al., 2004); perhaps individuals low in social engagement distinguish less between self and other than do those higher in social engagement. It could be the case that people who are lower in social engagement actually carry more representations from close others into representations of the self, thereby creating this lack of a clear preference for self-referential information.

There was no main effect of social engagement on these early stimulus processing peak latencies, suggesting that unlike in ASD (Marco et al., 2011), basic stimulus processing ability is intact in individuals low in social engagement, and does not contribute to observed latency differences specific to condition for these groups.

Previous research concerning neural correlates of hearing one's own name is scarce; interestingly, in the study most similar to the current study's auditory task, no latency effects were observed for P200 or P300 (Höller et al., 2011). Most of the available literature on name recognition focuses on viewing the own name rather than listening to the own name (e.g. Zhan, 2016). One study found that P300 components for auditory stimuli were more robust than those for visual stimuli (Bennington & Polich, 1999). Marginally longer P300 latency for those low in social engagement could be reflecting a prolonged process in working memory. This could reflect a difference based on real-life behavior: those high in social engagement may display shorter latency as an effect of a system that has had more practice (due to regular

exposure to self-referential stimuli, for example) than that of individuals who are low in social engagement.

P300 is known to reflect context updating during a task, sustained attention, and is known to be influenced by familiarity (Polich, 2007). In fact, it is this component in which the self-preference effect has been illustrated in past research. In prior research, auditory P300 was demonstrated in response to one's own name, but not to others' names (Folmer & Yingling, 1997). However, in this experiment, researchers were trying to demonstrate whether P300 would occur in response to one's own name versus an unkown name and used first names only. In another prior study, researchers demonstrated prolonged P300 latency in response to self-relevant words and phrases (Gray, Ambady, Lowenthal, & Deldin, 2004). For our name task, P300 latency did not differ when hearing names of close others and their own name for individuals low in social engagement, whereas individuals high in social engagement showed a self-preference effect in P300 latency; high SE individuals showed a much faster P300 response to hearing their own name than to the names of close others.

Our findings may point to difficulty processing self-relevant stimuli above the emotional relevance of familiarity for individuals low in social engagement, reflecting a similarity to individuals with ASD in the lack of differentiation neurally between self-relevant and emotion-relevant stimuli. Similarity in self-processing in individuals with any clinical diagnosis of ASD but who nonetheless show low social preferences may point to a neural connection between social processing and self-processing in general which may not be unique to ASD. Since this study was conducted in adults with already established social preferences and history, it is unclear whether these differences in self-

preference are innate or are the result of reduced exposure to social stimuli. Neural connections strengthen through continued practice or repeated exposure, so perhaps for individuals low in social engagement, the brain's systemic connections to self-relevant stimuli are less strong than those for individuals high in social engagement. Further study in young children both with and without ASD may help determine the extent to which this abnormality results from or precedes the establishment of style of social engagement.

The current study produced results both similar to and divergent from results of a previous study in which names were presented visually (Tacikowski, Cygan, & Nowicka, 2014). Names in this study came from four categories: own name, close other, famous person, and stranger. Participants viewed first and last names presented visually on a computer monitor and discriminated between familiar and unfamiliar names by pressing one of two buttons. In their study, larger P200 amplitudes were recorded in response to both own name and the name of close others. In our study, no differences in P200 amplitude were observed. However, we did see a difference in P2 latency for names. When hearing the name of the self or close other, individuals displayed longer latency than when hearing the name of a stranger. For N250, Tacikowski and colleagues (2014) noted larger N250 amplitudes to one's own name than to the unknown name. In the current study, we add to previous results in that we found longer N2 latency to own name. For P300, they found no amplitude differences between own name and close other, but did find a significant difference in amplitude between self and famous person or stranger and close other and famous person or stranger. In our study, P300 latency was shorter in response to own name; this result

converges with that of Tacikowski's study – P300 latency did not differ significantly between self and close other in their study, but there were significant differences in latency noted between the self or close-other and strangers or famous names.

This study had a few limitations that should be discussed. First, the sample size was small. Additionally, these individuals were all recruited through web-related methods or required to participate for course credit. This sample may not be generalizable to all individuals, being that there are individuals without use of technological resources who may show different or more extreme social preferences. Although additional research on the topic is necessary, the current research suggests that non-clinical individuals who live and function differently in the social world may in fact show different neural activation in response to names and faces that differ based on familiarity and self-relevance. Understanding the full scale of social function for non-clinical individuals and how it corresponds to neural activity is vital in building a knowledge base concerning the abnormal aspects of neural and social functioning, such as those reported in individuals with ASD and other neurocognitive disorders. Increasing sample size, including more trials in analyses, and replicating previously found results can all play a role in building understanding of the relationship between neural activity and the social world.

Table 1: Participant Descriptives by Group

Group	Males	Females	Total	Age Range	Mean Age	Mean AQ_SS	Mean BAPQ_aloof
High	1	9	10	18 – 53	27.3	0.7	1.6
Low	4	7	11	19 – 54	25.6	6.5	4.1

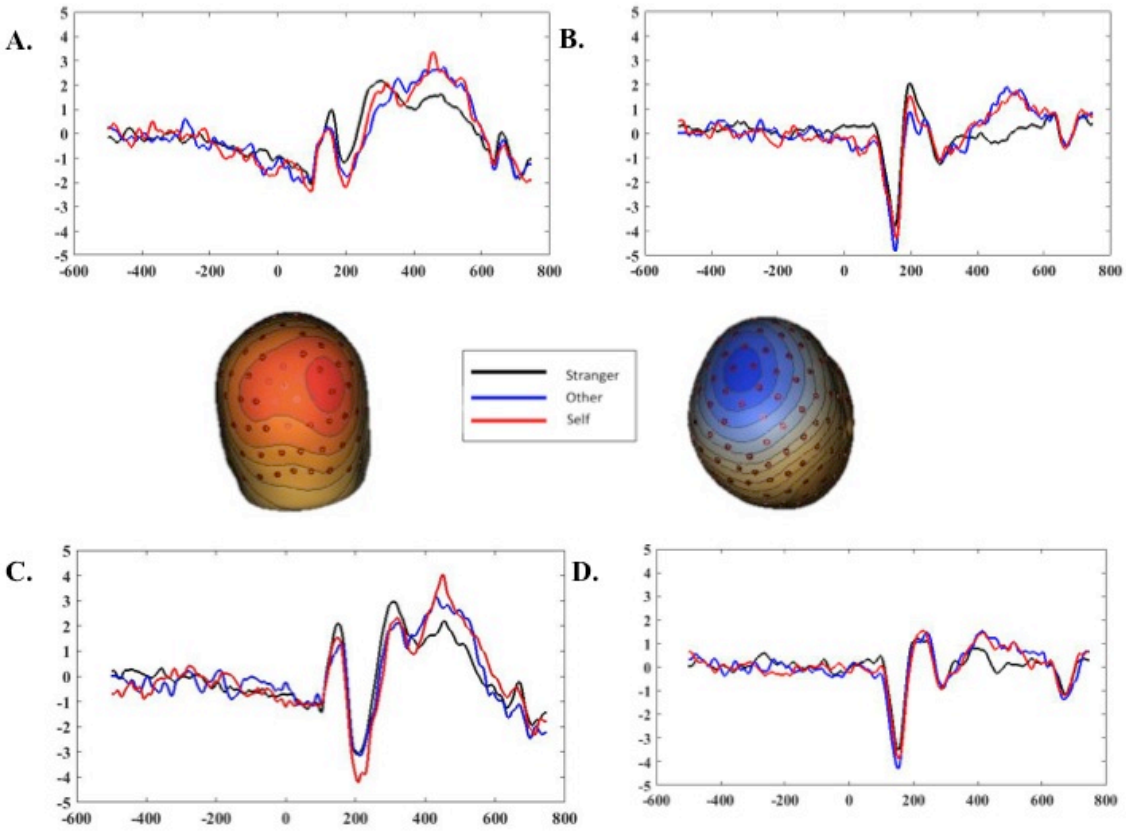


Figure 1. Scalp Component Activation and Topography for Faces.
Middle images represent topography averaged across groups for each component. (A). Component 1 waveform for High SE. (B). Component 2 waveform for High SE. (C). Component 1 waveform for Low SE. (D). Component 2 waveform for Low SE.

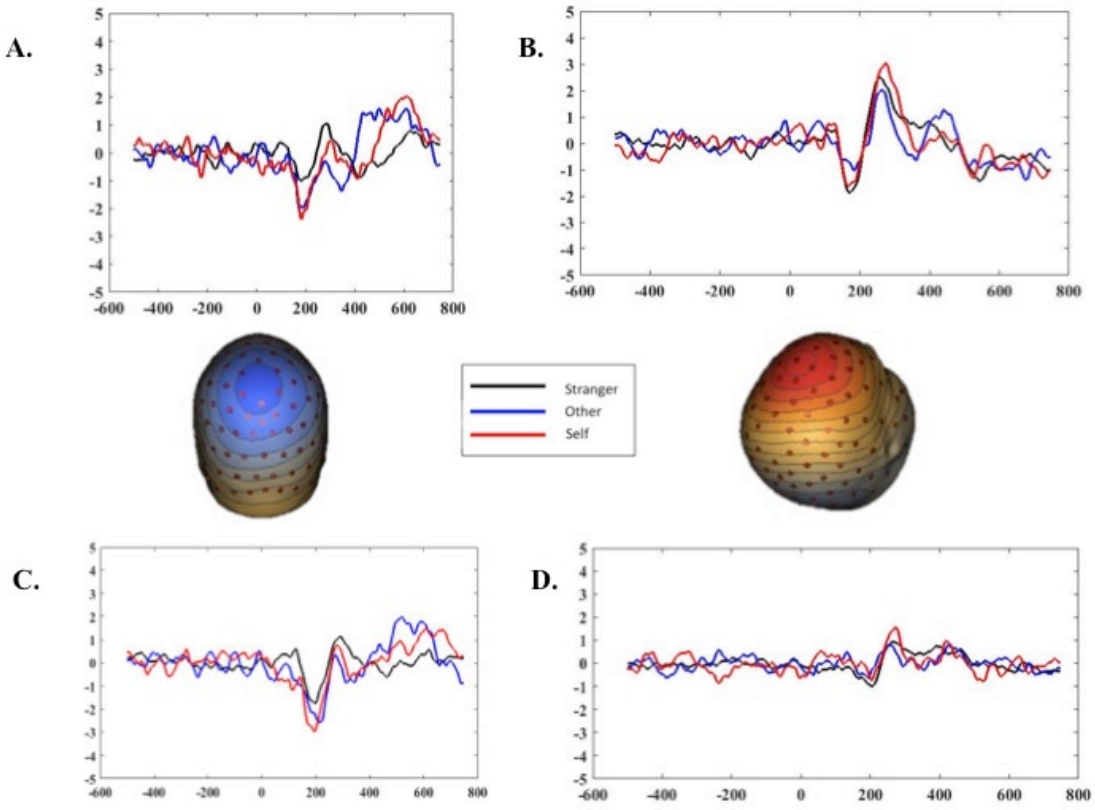


Figure 2. Scalp Component Activation and Topography for Names.
Middle images represent topography averaged across groups for each component. (A). Component 1 waveform for High SE. (B). Component 2 waveform for High SE. (C). Component 1 waveform for Low SE. (D). Component 2 waveform for Low SE.

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