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Distinguishing shyness and sociability in adults: An event-related electrocortical-neuroendocrine study

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ABSTRACT

Shyness and sociability are orthogonal personality dimensions, but little is known about how the two traits are instantiated in the brain and body. Using a 3-stimulus auditory oddball task, we examined whether shyness and sociability were distinguishable on P300 event-related potentials (ERPs) in processing task-relevant, novel, and standard auditory tones in 48 young adults. ERP amplitudes were measured at four midline scalp sites (Fz, FCz, Cz, Pz). We found that shyness, but not sociability, was related to reduced frontal novelty P300 amplitudes and to high emotionality. We also found that low baseline salivary cortisol levels mediated the relation between: (a) high shyness and reduced frontal P300 amplitudes to novel tones, and (b) high shyness and high scores of emotionality. We speculate that low baseline cortisol may serve as a putative mechanism influencing central attentional states of avoidance to threat and novelty and emotional arousal in adults who are shy.

Shyness and sociability are conceptually and empirically orthogonal personality traits operationalized by distinct motivational behaviors, with shyness linked to social inhibition and withdrawal-related tendencies, and sociability linked to social approach tendencies and a preference to be with others rather than being alone (Asendorpf, 1990; Cheek & Buss, 1981). The independence of shyness and sociability has been established in humans across development, including studies of children (Asendorpf & Meier, 1993; Coplan & Armer, 2007; Coplan, Prakash, O'Neil, & Armer, 2004; Tang, Santesso, Segalowitz, & Schmidt, 2016), adolescents (Mounts, Valentiner, Andrerson, & Boswell, 2006; Page, 1990), and adults (Eisenberg, Fabes, & Murphy, 1995; Schmidt, 1999; Schmidt & Fox, 1994; Sheeks & Birchmeier, 2007; but see Bruch, Gorsky, Collins, & Berger, 1989), across clinical populations (Goldberg & Schmidt, 2001; Jetha, Schmidt, & Goldberg, 2009), and across cultures, including German (Czeschlik & Nurk, 1995), Portugese (Neto, 1996), and Asian (Hussein, Fathy, Mawla, Zyada, & El-Hadidy, 2011) samples. The independence of these two dimensions also has been reported in nonhuman animals (for a review, see Reale, Reader, Sol, McDougall, & Dingemanse, 2007).

Beyond distinguishing shyness and sociability on behavioral and self-report measures, accumulating evidence supports the notion that the two personality traits are associated with specific physiological correlates of stress reactivity and vulnerability across autonomic and central measures. At a peripheral psychophysiological level, shyness and sociability have been distinguished in children in their everyday environments on heart rate measures (Asendorpf & Meier, 1993) and in young adults during the anticipation of unfamiliar social interactions on heart rate and heart rate variability measures (Schmidt & Fox, 1994).

At a neurophysiological level, distinct patterns of frontal electroencephalogram (EEG) asymmetry and event-related potentials (ERPs) have distinguished shyness and sociability in adult and child studies. For example, shy adults display greater relative right frontal EEG activity, whereas sociable adults exhibit greater relative left frontal EEG activity during rest (Schmidt, 1999); these patterns have also been replicated in clinical samples of adults with schizophrenia (Hussein et al., 2011; Jetha et al., 2009). In typically developing 10-year-olds, we recently found that shyness, but not sociability, was linked to higher P300 ERP amplitudes in the

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processing of task-relevant and background auditory tones (Tang et al., 2016).

1. Shyness, vigilance, and sensory information processing in the brain

Research suggests that shy individuals are hypervigilant to threatening information and are biased to perceive ambiguous or neutral stimuli as threatening in social contexts. This hypervigilance has been linked to differential affect-related attentional mechanisms during early phases of processing, evident in a series of behavioral (e.g., Brunet, Heisz, Mondloch, Shore, & Schmidt, 2009; Matsuda, Okanoya, & Myowa-Yamakoshi, 2013), neuroimaging (e.g., Beaton et al., 2008), and ERP (e.g., Jetha, Zheng, Schmidt, & Segalowitz, 2012, Jetha, Zheng, Goldberg, Segalowitz, & Schmidt, 2013) studies that used threatening and negative facial expressions as experimental stimuli. Hypervigilance and reactivity in both social *and* non-social novelty are also signatures of other shy-fearful phenotypes, such as behavioral inhibition (BI), a temperamental feature of shyness identified in infancy (see Henderson, Pine, & Fox, 2015; for a review).

In understanding the extent to which typically developing children who are shy process non-social sensory information differently in the brain, we recently examined the N200 (a negative peak at 200–400 ms) and P300 ERPs (a positive peak at 300–500 ms), which increase in amplitude after stimulus onset to target and novel tones as opposed to standard tones in a 3-stimulus auditory oddball task (Tang et al., 2016). Although we found no relation between N200 amplitudes and children's shyness, the rationale for examining the P300 in that study and the present study was for its hypothesized role in attentional and working memory operations (Donchin, Karis, Bashore, Coles, & Gratton, 1986; Polich, 2007), and the positive relations between P300 amplitudes and high arousal levels that have been linked to personality (Brocke, Tasche, & Beauducel, 1997; DePascalis, 2004; Ditraglia & Polich, 1991; Sternberg, 1992; Wilson & Languis, 1990). Because higher levels of basal arousal and vigilance are common physiological components of shyness and other related anxiety constructs, such as BI and social anxiety, the P300 is a potential neurocognitive correlate of these shy-fearful phenotypes. Indeed, we recently found that 10-year-old children who were higher in shyness elicited higher P300 amplitudes to target and standard tones, while P300 amplitudes across all conditions were unrelated to sociability (Tang et al., 2016).

Using a similar auditory oddball task, others have found that adolescents characterized by high BI across childhood with higher novelty P300 amplitudes were more likely to have a lifetime diagnosis of an anxiety disorder compared to adolescents characterized by low BI (Reeb-Sutherland et al., 2009). However, the extant literature is limited to child and adolescent samples, and to the best of our knowledge, shyness, sociability, and the novelty P300 have not been examined in adults. As well, relatively little is known regarding whether the processing of social information generalizes to non-social information processing in shyness.

The primary goal of the present study was to extend our recent findings with children by examining whether shyness and sociability were distinguishable on the P300 in adults, using the same 3-stimulus auditory oddball task and ERP measures we used with children (e.g., Tang et al., 2016). We did not directly compare our child and adult samples, as there were differences in the ERP waveforms. For example, the N200 amplitudes were more negative in the target and novel (rare stimuli) conditions versus the standard (frequent stimulus) condition in adults, but the reverse pattern was observed in children. Possible developmental differences in the amplitude and latency of the P300 component that reflect brain maturation for neural processing power and speed across the lifespan have also been documented (see Van Dinteren, Arns, Jongsma, & Kessels, 2014, for the results of a recent meta-analysis).

2. Shyness, neuroendocrine functioning, and emotional arousal

In addition to brain measures of arousal/reactivity during information processing, neuroendocrine and subjective emotional arousal measures might also offer insight into shyness as arousal manifests on multiple levels in the brain and body. One neuroendocrine measure that has been used to study shyness is cortisol. Cortisol is a predominant glucocorticoid produced by the hypothalamic-pituitary-adrenal axis (HPA-axis) in humans and it has been used to index stress reactivity and regulation in shy-fearful phenotypes, given the basic function of increased cortisol release is to mobilize energy for action during fight or flight situations mediated by the sympathetic nervous system.

At baseline, changes in cortisol levels are observed in shy-fearful phenotypes across development. In early childhood, BI and shy children exhibit increases and/or high basal cortisol levels (Kagan, Reznick, & Snidman, 1988; Schmidt et al., 1997). By middle childhood, both high and low basal cortisol levels are observed in shy children (Schmidt, Santesso, Schulkin, & Segalowitz, 2007). By young adulthood, decreases and/or low basal cortisol are observed in shy adults, with lower levels negatively correlated with higher self-report social anxiety (Beaton et al., 2006, 2013).

The neuroendocrine system may also influence emotion processing and regulation in shy individuals. For example, we recently found that variation in the salivary cortisol awakening response (CAR) in shy adults is predictive of modulation in a distinct pattern of brain regions for processing angry faces relative to non-shy adults (Tang, Beaton, Schulkin, Hall, & Schmidt, 2014).

Others measures that have been used to index sympathetic arousal/reactivity are subjective measures of emotionality. Emotionality is the tendency to be aroused to negative emotions, including distress, fear, and anger, that is thought to have a physiological basis (Buss & Plomin, 1984). Indeed, emotional responding to emotionally charged stimuli is related to increased physiological reactivity across different measures (e.g., Bradley, Miccoli, Escrig, & Lang, 2008; Colder, 2001). There is also a positive relation between subjective reports of emotionality and shyness (e.g., Buss & Plomin, 1984; Eisenberg, Shepard, Fabes, Murphy, & Guthrie, 1998) that suggests shy individuals have a tendency to experience negative emotions more intensely. Accordingly, it is possible that sympathetic reactivity in shy individuals can influence their subjective levels of emotionality.

Following a multi-component approach, the second goal of the present study was to examine the relations among shyness, ERP and neuroendocrine responses, and emotionality. Relatively few studies have addressed the potential mechanism(s) underlying links between shyness and brain-behavior relations.

3. The present study

Based upon our two goals, we first examined the relations among shyness, sociability and ERP responses to a 3-stimulus auditory oddball task in a sample of undergraduates. Given shyness and sociability are conceptually and empirically independent constructs, and shyness is linked to hypervigilance in information processing, we predicted that increases in shyness, but not sociability, would be related to higher P300 amplitudes to target, novel, and standard tones, with the highest to novel tones, given unfamiliarity-novelty is salient in signaling danger and maintaining shyness reflected by greater attention allocation (e.g., Kagan, 1994).