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Heart rate variability during adolescent and adult social interactions: A meta-analysis

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ABSTRACT

Social interaction skill is important for psychological wellbeing, stress regulation, protection from disability and overall life satisfaction. Increase in activity of the vagus nerve, measured by heart rate variability (HRV), is associated with social interaction skill and decreased stress. In this meta-analysis we collated statistics from thirteen studies consisting of 787 participants who were participating in social interactions while HRV was simultaneously collected. Results revealed that while dyadic social interactions do not increase HRV generally from a baseline state, negative dyadic social interactions decrease HRV in a manner similar to the Trier Social Stress Task. Further, participants with psychopathology do not show cardiac autonomic flexibility during social interactions as indicated by reductions under stress and increases with subsequently positive social interactions. The role of age, gender and HRV index were also examined as potential moderators of HRV. Implications for health and wellbeing resulting from exposure to negative social interactions are discussed.

1. Introduction

Social interaction skill is central to well-being and healthy functioning (Hari & Kujala, 2009; Ishii-Kuntz, 1990). These skills are associated with many positive health outcomes, levels of stress and disease (Ono et al., 2011), disability, and life satisfaction (Nezlek, Richardson, Green, & Schatten-Jones, 2002). Some mental illnesses are characterized by an inability to effectively regulate social interactions (e.g., autism, schizophrenia) (Klin, Volkmar, & Sparrow, 1992), while social isolation and rejection increases chronic stress (Blackhart, Eckel, & Tice, 2007; Bolger, Delongis, Kessler, & Schilling, 1989; Cacioppo & Hawkley, 2003) and is linked to psychological and physical health problems (Cacioppo & Hawkley, 2003; House, 2001).

Social interactions require an individual to engage in dyadic-based situations (Griffin & Gonzalez, 2003) and necessitate capacity for stress regulation during social tasks (Heinrichs & Gaab, 2007). There has been growing interest in studying biological markers associated with social interaction skill, with biological systems underlying social effectiveness proposed (Porges, 2007). Porges (2007), in particular, has described the activity of the myelinated vagus in contributing to the control of facial muscles, middle ear, and laryngo-pharyngeal muscles, which are critical for understanding social cues and responding effectively (through facial expression or vocalization). Moreover, Porges (2003) has argued that the myelinated vagus can be differentially disrupted by stress to disable effective social interaction, through the activation of the adreno-cortical system. The role of the vagus in states of stress and social interaction or relaxation is referred to as Polyvagal theory (Porges, 2007).

The ability of the body to regulate autonomic activity in a dyadic interaction, or stressful and challenging social contexts, has been described as autonomic flexibility (Appelhans & Luecken, 2006; Friedman & Thayer, 1998). Autonomic flexibility refers to adaptive changes in arousal, respiration, heart rate, and attention that arise from parasympathetic nervous system regulation, and is linked to increases in vagal tone (Kok & Fredrickson, 2010). Thus, effective social interaction may reflect both increased activity of the myelinated vagus, leading to flexible and responsive facial, vocal, and auditory systems in the social environment, and effective stress regulation with stressful social contexts, as indicated by a reduced adreno-cortical response. While Polyvagal theory is not without critics (Grossman & Taylor, 2007), alternate models also highlight the importance of the vagus nerve for social interaction. The Neurovisceral Integration Model, for instance, conceptualizes cardiac variability as an index of autonomic nervous system regulation,

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related to attentional and affective control (Thayer & Lane, 2000). These authors argue HRV may play a role in the organization of physiological resources to assist goal directed behavior, an important component of social interaction skill. Further, the authors suggest the GABAergic, and other inhibitory pathways, associated with the amygdala may play a role in regulating autonomic nervous system outflow (Thayer & Lane, 2009).

Heart rate variability (HRV) has been used to approximate vagus nerve outflow. It represents the beat-to-beat variation in the duration of the R–R interval (heart period), reflecting complex interactions between parasympathetic, sympathetic, mechanical and other factors on the pacemaker located at the sinoatrial node of the heart (Billman, 2011). When individuals are in a relaxed or resting state, HRV is generally increased, reflecting greater parasympathetic activity that facilitates social interaction (Porges, 2007). In contrast, when individuals are faced with challenging or stressful events, a reduction in vagal influence on the sino-atrial node inhibits parasympathetic nervous system activity, preparing the person for a 'flight or fight' response (Porges, 2007).

Autonomic flexibility appears to be associated with refined social skills in dyadic interaction contexts and improved regulation in stressful or challenging social environments (Appelhans & Luecken, 2006). For instance, when pairs of women discussed a previously seen upsetting film, those who regulated their emotions showed higher HRV than those who did not regulate their emotions (Butler, Wilhelm, & Gross, 2006). Discussing a major life event with a supportive friend has also been associated with higher HRV, whereas discussing with an ambivalent friend has been associated with lower HRV (Holt-Lunstad, Birmingham, & Light, 2008). Lower HRV was even associated with poorer recovery after anticipating a stressor (Waugh, Panage, Mendes, & Gotlib, 2010). Thus, HRV appears to predict regulation of emotions in both positive and supportive social interactions and stressful or challenging social contexts. Furthermore, the valence of a dyadic social interaction task (i.e., positive or negative) may moderate the direction of HRV change during social interactions in a manner predicted by Polyvagal theory. In one study, negative appraisal by an experimenter was associated with decreased HRV, while an apology led to HRV increasing back to baseline levels (Whited, Wheat, & Larkin, 2010). Similarly, the experience of failure in a stressful alarm test decreased HRV in adolescents, but reuniting with parents increased HRV (Willemen, Goossens, Koot, & Schuengel, 2008).

A number of other factors are known to potentially influence HRV including age, gender and respiration rate. Age can significantly impact measurements of HRV (Antelmi et al., 2004) with middle aged participants recovering from a marital disagreement displaying lower HRV than older participants (Smith et al., 2009). Gender also appears to play a role in moderating HRV responses in an index specific manner with one study showing that while women score higher on some indexes of HRV, men score higher on others (Antelmi et al., 2004). A study into the HRV responses of married couples during collaboration and disagreement tasks showed that while some women displayed greater autonomic flexibility across tasks than men did, gender related differences increased with age (Smith et al., 2009). Other factors that have demonstrated an impact on HRV include respiration rate (Quintana & Heathers, 2014; Song & Lehrer, 2003), cognitive load (Thayer, Hansen, Saus-Rose, & Johnsen, 2009) and posture (Lipsitz, Mietus, Moody, & Goldberger, 1990).

In this meta-analysis, we assessed the impact of dyadic social interaction tasks on HRV. Based on Porges' Polyvagal theory (Porges, 2003), we hypothesized that HRV responses would differentiate between states of social disengagement and stress and those of relaxation (baseline) and social engagement. In addition, we directly compared these results against a well-known social stress task that does not involve dyadic social interaction between participants, the Trier Social Stress Task (TSST). In the TSST, participants deliver a speech without feedback so, while stressful, it does not involve reciprocated dyadic social interaction. Past research suggests the task results in decreases in HRV from baseline measures (Codispoti, Mazzetti, Baldaro, Tuozzi, & Trombini, 2001; Fagundes et al., 2011; Fagundes, Diamond, & Allen, 2012; Mauss, Wilhelm, & Gross, 2003; Page-Gould, Mendes, & Major, 2010; Waugh et al., 2010). Inclusion of the TSST allows us to determine whether negative reciprocated, dyadic social interactions decrease HRV to the extent of an established acute social stressor task. Finally, this meta-analysis will examine the influence of psychopathology on HRV responses during social interactions. Adults with schizophrenia (Bär et al., 2007) anxiety disorders (Alvares et al., 2013; Chalmers, Quintana, Abbott, & Kemp, 2014) major depressive disorders (Henje Blom, Olsson, Serlachius, Ericson, & Ingvar, 2010; Kemp et al., 2010), and alcohol dependence (Quintana, McGregor, Guastella, Malhi, & Kemp, 2013) show reduced HRV generally. Some researchers have argued that HRV during social interactions may differ in individuals with psychopathology; specifically those associated with social dysfunction (Porges, 2003).

A number of moderator variables were included based on availability of data in the current literature. These included psychopathology, age, gender and type of HRV index used. We did not expect gender to play a role in determining cardiovascular responses to social interaction with pooled indices as while some indices are higher in men others are higher in women (Antelmi et al., 2004) and may equate when pooled across type of HRV index. However, we hypothesized that there would be decreased reactivity in older participants.

2. Methods

2.1. Criteria for considering studies for this review

All studies that evaluated HRV in social tasks in adolescents and adults were included (excluding studies in children aged <12 years old). All studies examined HRV as explicitly measured during performance of differing task types and compared to a baseline measure.

2.2. Inclusion and exclusion criteria

Participants included in this review were either typically developing controls or adolescents and adults characterized as having psychopathology (Smeekens, Didden, & Verhoeven, 2013; Willemen, Schuengel, & Koot, 2009) or trait markers of social anxiety (Mauss et al., 2003). Tasks used to study social behavior in adolescents and adults were similar in design, however, to ensure age effects did not confound results, we conducted moderator analyses where possible.

2.3. Types of tasks

Both dyadic tasks such as 'cyberball' and marital conflict discussion tasks as well as non-interactive tasks, where participants were delivering a speech with no feedback, were used (see Table 1 for specific tasks). All studies included involved a participant wearing a device that collected interbeat intervals during baseline periods as well as during the social performance task.

2.3.1. Baseline tasks

The control condition used across studies requires participants to sit as still as possible for a short period of generally 5–15 min (Hastings et al., 2008).

2.3.2. Trier social stress test

The Trier Social Stress test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993) consists of the active performance of a speech and mental arithmetic task, during which a committee threatens the self-esteem of the participant. The committee pretends to evaluate the participant's performance, providing no signs of social support, leading the participant to question the accuracy of their own behavior. The participant experiences stress as a result of self-questioning and feelings of lack of control (Het, Rohleder, Schoofs, Kirschbaum, & Wolf, 2009). We included the TSST as a comparator. While it is a social stress task, it does not involve any reciprocal dyadic interaction (Shahrestani, Stewart, Quintana, Hickie, & Guastella, 2014). Other examples of reciprocal dyadic interaction tasks include those where only one experimenter is present, rather than a panel, and this experimenter interacts with the participant in order