SOCIAL ANXIETY, CONTEXT, AND AFFILIATION: THE MEDIATING ROLE OF INTERPERSONAL AUTONOMIC PHYSIOLOGY

By

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ABSTRACT

This study utilized the Vulnerability-Stress-Adaptation model (Karney & Bradbury, 1995) to investigate how vulnerability (i.e., subclinical levels of social anxiety) and stress (i.e., manipulated social contexts) affected an interpersonal outcome (i.e., affiliation) through an adaptive process (i.e., interpersonal autonomic physiology). The present study utilized data from 58 same-sex, same ethnicity stranger dyads (N =116) who participated in a between-subjects 2 (Social interaction: Talking vs. No Talking) by 2 (Interaction orientation: Competition vs. Cooperation) experiment. Specifically, participants completed a knot-tying task with either a cooperative or competitive framing while either talking or remaining silent. Autonomic nervous system activity was measured continuously with electrocardiograph for both individuals during the interaction. Covariation of interbeat intervals was used to generate two dynamic profiles of interpersonal autonomic physiology. One profile showed an amplifying (i.e., unstable) pattern, while the other showed a damping (i.e., stable) pattern over time. It was hypothesized that conditions which decreased sociality (e.g., competition vs. cooperation) and required disclosure (talking vs. no talking) would be particularly stressful for dyads in which one or both partners were socially anxious. Additionally, it was hypothesized that this stress would be reflected in interpersonal autonomic physiology covariation (i.e., depicted by patterned trajectories), and therefore would reduce affiliation tendencies within the dyads. Models for hypothesis testing were estimated using Bayesian statistics. These hypotheses were not supported, however an exploratory analysis revealed that interpersonal autonomic physiology profile was a likely predictor of perceived similarity to partner after the task. More specifically, the unstable dynamic predicted more perceived similarity to partner, which suggests that interpersonal autonomic physiology could play a role in initial relationship formation.
Introduction

“Human interpersonal relationships are complex. To function aboard a starship, or in any human activity, you must learn to form relationships.”

– Data, Star Trek: The Next Generation

The need to establish and maintain interpersonal relationships is a basic human motivation (Baumeister & Leary, 1995), to the point that the maintenance of stable relationships is crucial for survival (Bowlby, 1969; Maslow, 1943). As seen from decades of work based on attachment theory (see Ravitz et al. 2010 for a review), early social relationships have implications not only for immediate survival but for relationships developed later in life. According to Maslow (1943), love and belongingness are prerequisites for self-actualization. Moreover, people with strong interpersonal relationships live longer than those with weaker relationships (Holt-Lunstad et al., 2010). This established work on the importance of interpersonal relationships necessitates an investigation into what factors and contexts support or hinder the formation of affiliative bonds.

Extant research on physiology shows that changes in the autonomic nervous system (e.g., increased or decreased heart rate) during social interactions are associated with prosocial behavior and emotion regulation (Porges, 2001), which are necessary components of relationship building. In some cases, individuals show mutual, covaried changes in autonomic physiology which predicts affiliative outcomes for both individuals (Danyluck & Page-Gould, 2018). Additionally, research in the social-cognitive domain has shown that humans are capable of making decisions about whom they want to establish relationships with in the first few minutes of the interaction (Berg & Clark, 1986). Taken together, these literatures raise the question of whether the affiliation process is the same across all individuals. For instance, anxiety regarding
social situations is common and associated with a host of cognitive, physiological, and behavioral correlates, including fear of rejection, autonomic dysregulation, and avoidance of social situations, respectively. In extreme cases, these manifestations warrant a diagnosis of social anxiety disorder (i.e., marked fear or anxiety about one or more social situations in which the individual is exposed to possible scrutiny by others; DSM-5; American Psychiatric Association, 2013). Notably, social anxiety disorder is one of the most common psychiatric disorders in the United States. In fact, subclinical levels of social anxiety are associated with similar outcomes to those seen in social anxiety disorder (Fehm et al., 2008). Given the ubiquity and negative sequelae of social anxiety, there is a need to understand the relationship between social anxiety and affiliation, with a specific emphasis on determining the role of interpersonal autonomic physiology.

Theoretical Framework

This study is guided by the Vulnerability-Stress-Adaptation (VSA) model (Karney & Bradbury, 1995). Although this model is usually adopted to predict change and stability over the course of marriage, this work applied the model to stranger dyads who were in the initial phases of interaction. Broadly, the VSA model accounts for the stressful events (e.g., economic strain or transition to parenthood; Cohan & Bradbury, 1997; Don & Mickelson, 2014) that dyads encounter, the enduring vulnerabilities (e.g., attachment orientation or personality traits; Li et al., 2020; Pasch et al., 1997) that dyads bring to the interaction, and the adaptive processes (e.g., reappraisal, problem solving, and attributions; Bradbury & Fincham, 1992) through which dyads tackle difficult situations. In other words, this model suggests that the capacity of a dyad to adapt depends on the degree of stress experienced and the enduring vulnerabilities that each person brings to the interaction. Dyads’ adaptive processes gradually influence outcomes related to the
relationships (e.g., marital satisfaction and divorce; Randall & Bodenmann, 2009; Rodrigues et al., 2013) and subsequent outcomes may influence adaptive processes, which highlights the bidirectional relationship between adaptive processes and outcomes.

Although this is one of the first studies to utilize the VSA model for strangers, the model lends itself well to an initial encounter between two strangers. First, vulnerabilities refer to enduring traits that an individual brings to a situation. Vulnerability indirectly impacts social outcomes via adaptive processes (see Figure 1). In the current study, social anxiety is conceptualized as vulnerability, given that levels of social anxiety manifest cognitively (e.g., fear of rejection or evaluation) and behaviorally (e.g., lack of eye contact or fidgeting; Heerey & Kring, 2007; Wenzel et al., 2005) and have implications for social outcomes (e.g. avoidance of social situations and less self-disclosure; Ledley et al., 2017; Piccirillo et al., 2016). Additionally, negative affectivity, as seen in social anxiety, is associated with experiencing life events as more stressful in cross-sectional, longitudinal, and experimental studies (Bolger & Schilling, 1991; Watson & Pennebaker, 1989).

Second, stressful events are defined as any situational demands that exceed individuals’ or dyads’ capacity to cope (Karney & Bradbury, 1995). Stressful events include chronic or acute circumstances that dyads encounter (Karney & Bradbury, 1995). In the present study, having to participate in a challenging social context is conceptualized as a stressful event. Specifically, the degree of sociality (i.e., talking vs. no talking) and the type of interaction (i.e., competitive vs. cooperative) were manipulated. Previous research has shown that competition is subjectively stressful and that negative interpersonal outcomes are associated with competitive compared to cooperative contexts (Deutsch, 2011, pp. 29-30). Additionally, given that socially anxious individuals are reluctant to speak during social interactions (Schlenker & Leary, 1985; Leary et
al., 1987), talking conditions could be especially stressful for those with social anxiety. In accordance with the VSA model’s conceptualization of stressful events, the manipulations are acute, external events that the newly interacting dyads encounter.

Third, adaptive processes are behaviors or regulatory mechanisms that are utilized in response to stressful events (Karney & Bradbury, 1995). For the present study, adaptive processes are operationalized as individuals’ autonomic nervous system (ANS) activity over the course of an interaction with a stranger. Intrapersonal ANS activity is associated with social engagement (i.e., making social and emotional connections with people; Geisler et al., 2013; Porges, 2001) and emotion regulation (i.e., modifying the emotions one experiences, when they are experienced, and how one experiences and expresses them; Gross, 2016). Moreover, emotions, which involve changes in the ANS, can facilitate (mal)adaptive responses to problems related to both relationship formation and maintenance (Butler, 2011).

Additionally, interpersonal ANS activity, as evidenced by covaried changes in an ANS signal with another individual, predicts relationship outcomes, including affiliation and relationship quality (Danyluck & Page-Gould, 2018; Levenson & Gottman, 1985). Effective interpersonal regulation of ANS activity, as reflected in stable or unstable patterns of physiology, could be indicative of adaptation during the initial interaction. In the current study, ANS activity is measured by electrocardiogram continuously throughout the interaction to obtain interpersonal autonomic physiology profiles. Lastly, given that a) affiliation is an important predictor of initial relationship formation and b) social anxiety predicts affiliation-related behaviors (Campbell et al., 2015; Heerey & Kring, 2007), affiliation is conceptualized as the outcome in this study.
Social Anxiety

The lifetime prevalence of social anxiety disorder is estimated to be 12% in the United States, making it one of the most common psychiatric disorders (Ledley et al., 2017). Individuals with social anxiety have an intense fear of situations in which the individual may be judged, negatively evaluated, or rejected (Spence & Rapee, 2016). Individuals with social anxiety may worry about acting or appearing visibly anxious (e.g., blushing, stumbling over words), or being viewed as stupid, awkward, or boring (Spence & Rapee, 2016). Thus, individuals who are socially anxious may avoid social situations or endure them with great distress (Ledley et al., 2017). Recent work has shown that even subclinical levels of social anxiety (i.e., social anxiety that does not meet the DSM-5 criteria for social anxiety disorder) are associated with similar outcomes found in social anxiety disorder (Crisan et al., 2016; Fehm et al., 2008). For example, those with subclinical levels of social anxiety report high negative affect, increased self-focused attention, and negative interpretation biases such that neutral social information from the environment may be interpreted as negative (Hofman, 2007; Kashdan et al., 2004). Additionally, individuals with social anxiety exhibit cognitive errors regarding social experiences which include over-estimating both the likelihood of a negative interaction and the potential consequences (Hofman, 2007). Taken together, this work suggests that the intrapsychic tendencies associated with social anxiety have implications for intrapersonal and interpersonal outcomes.

Interpersonal Communication in Social Anxiety

Previous work on communication patterns among socially anxious individuals has shown that they are less likely to initiate, speak, and disclose personal information during a conversation (Schlenker & Leary, 1985; Leary et al., 1987). In an evaluative context, DePaulo et al., (1990)
found that socially anxious individuals spent less time talking and revealed less about themselves compared to non-socially anxious individuals. Leary et al. (1987) reported that socially anxious individuals, compared to non-socially anxious individuals, used more negative self-disclosure statements (i.e., self-derogating statements) during a 5-minute conversation period with a sample of same-sex dyads. Furthermore, it has been shown that participants who report high levels of shame or anxiety fall silent or remain silent during an interaction (Ablamowicz, 1992; Voncken & Bogels, 2008), which leads to awkward silences or pauses that are unlikely to be broken by the socially anxious individual (Schlenker & Leary, 1985). Regarding interpersonal relationships, Davila and Beck (2002) found that high levels of social anxiety were associated with greater fear of expressing emotions. Similarly, Kashdan et al. (2004) found that greater experiential avoidance during a self-disclosure conversation predicted increases in social anxiety for the remainder of the conversation compared to individuals in a small talk (i.e., no intimate disclosure) context. Thus, individuals who are socially anxious may find disclosure-related conversations to be stressful, especially if the other person is a stranger.

_The Interpersonal Cycle of Social Anxiety_

Socially anxious individuals may experience a self-perpetuating interpersonal cycle in which expectations of negative evaluations elicit responses from people that maintain social assumptions (Alden & Taylor, 2004). In other words, socially anxious individuals may behave in ways that create the situation that they fear or try to avoid. There are several ways in which this cycle can be reinforced. First, given the internal demands of social anxiety (e.g., fear of rejection or evaluation), sustaining attention to the interaction and presenting positive social cues may be difficult among individuals with social anxiety (Perowne & Mansell, 2002). Additionally, the psychological tendencies associated with social anxiety have behavioral correlates, including
avoidance of eye contact, infrequent smiling, and fidgeting (Heerey & Kring, 2007; Wenzel et al., 2005). Among non-socially anxious individuals, these overt signals of social anxiety predict less similarity to and desirability of future interactions with an anxious partner (Papsdorf & Alden, 1998). Second, socially anxious individuals may rely on safety behaviors (i.e., actions intended to prevent feared outcomes; Ledley et al., 2017). Safety behaviors can be cognitive (e.g., excessive rehearsing or memorization) or behavioral (e.g., only speaking to people one knows at social gathering) and are associated with decreased attention to the interaction at hand (Piccirillo et al., 2016). Third, as discussed earlier, individuals with social anxiety are less prone to self-disclosure and discussion of emotional experiences compared to non-socially anxious individuals (Piccirillo et al., 2016; Kashdan et al., 2014).

Paradoxically, these cognitions and behaviors that may stem from a desire to reduce anxiety and avoid stressful situations maintain the interpersonal cycle in social anxiety (Hofman, 2007). Engagement in excessive regulatory processes and avoidance during social situations lessens the connection with the ongoing experience, which can cause a person to be less responsive to positive rewards in the environment (e.g., the person is less likely to catch explicit or implicit cues that the interaction is going well) and will thereby reduce the frequency of positive events and the opportunity to experience the associated positive emotions (Gross & John, 2003). This process has negative implications for interpersonal outcomes. For example, Heerey and Kring (2007) showed that mixed dyads of socially anxious and non-socially anxious individuals rated their interactions as less smooth and coordinated than dyads comprised of non-socially anxious individuals. Over the course of an interaction, a less socially anxious individual may begin to mimic the socially anxious person both cognitively (e.g., become more self-conscious) or behaviorally (e.g., display defensive body posture or reduce eye contact; Garcia et
al., 1991) which shows that socially anxious individuals may be “pulling” expectation-consistent reactions from individuals (Alden & Taylor, 2004).

**Social Contexts**

Social interactions commonly involve cooperation with others. Cooperation is a process whereby two or more individuals work together toward the achievement of shared or complementary goals with common behavioral effects (Vanutelli et al., 2018). In cooperative situations, the outcomes are linked such that joint outcomes are dependent on both partners’ actions. Cooperative contexts have been associated with favorable interpersonal relations (e.g., greater likelihood to initiate friendship), lower distress, and higher self-esteem for both parties (Deutsch, 2011, p. 29). In contrast, another common type of social interaction involves competition. Competition is a situation in which a person’s success depends on outperforming others, including individuals or groups (Deutsch, 1949). In comparison to the positive outcomes seen in cooperation, competition is defined by impaired communication and mutual negative attitudes (Deutsch, 2011, p. 30). Competition can produce affective states that include anxiety and anger (Deutsch, 2011, p. 210). Past studies examining competitive contexts and social anxiety showed that behaviors associated with social anxiety were perceived as submissive (Gilbert, 2001). For example, Weeks et al. (2011) found that social anxiety was associated with body collapse (i.e., slumped posture, lowered head) during a competitive task among men. Furthermore, studies have shown that individuals with social anxiety disorder exhibit fewer cooperative (e.g., smiling) and dominant behaviors (e.g., direct eye gaze) than non-anxious participants during an initial interaction (Farabee et al., 1993; Horley et al., 2003 Walters & Hope, 1998). Additionally, increased vocal pitch was associated with higher levels of social
anxiety among men completing a competitive task (Weeks et al., 2011). In sum, the stresses induced by competitive circumstances may be exacerbated among those with social anxiety.

**Autonomic Physiology**

The autonomic nervous system (ANS) is comprised of the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS). The two branches work together to regulate organ functioning in the cardiac, respiratory, and endocrine systems. Classically, the SNS is called “the fight or flight” system which assists in arousal and energy expenditure that ready the body for action. The PNS, colloquially called the “rest and digest” system, aids in decreased arousal, energy storage, and recuperation (Levenson et al., 2016). The SNS and PNS work together to balance inputs based on environmental demands (Porges, 2003; Polyvagal Theory). Physiological signals from the ANS can be distinguished by the degree of SNS and PNS influence. For example, heart rate (HR), or the time interval between heartbeats, reflects the joint action of the SNS and PNS on the heart (Levenson et al., 2016). Heart rate variability (HRV) is thought to be reflective of autonomic flexibility, or the ability of the ANS to respond dynamically to environmental demands and maintain homeostasis (Friedman & Thayer, 1998). Autonomic flexibility is associated with environmental engagement and attention while autonomic inflexibility (e.g., low HRV) is associated with pathology (e.g., cardiovascular disease and anxiety disorders; Friedman & Thayer, 1998).

There is mounting evidence that ANS activity is associated with intrapersonal processes (e.g., affect and emotion regulation) and interpersonal processes (e.g., prosocial behavior; Ekman et al., 1983; Grossman & Taylor, 2007; Kreibig, 2010; Porges, 2003). The ANS provides substrates for affective processes which are essential components of social interactions. During a social interaction, the ANS regulates the ability to express emotions which thereby determines
the quality of social contact and communication (Porges, 2001). Furthermore, the ANS can rapidly regulate cardiac output to support engagement or disengagement with one’s environment (Porges, 2003). More specifically, the SNS activity readies the human for interaction, while the PNS acts in a regulatory capacity in response to the ongoing interaction (Porges, 2003). In short, ANS functioning is an important regulator of affect and social behavior.

**Autonomic Physiology and Social Anxiety**

Autonomic inflexibility is found across anxiety disorders (Pittig et al., 2013). More specifically, anxiety disorders are characterized by atypical ANS control in the cardiac domain (Friedman, 2007). For example, reduced heart rate variability (HRV) has been found in anxiety disorders, including social anxiety (see Chalmers et al., 2014 for a meta-analysis). Friedman and Thayer (1998) found that individuals with anxiety exhibited less HRV as measured by interbeat interval (i.e., IBI; the time between consecutive heartbeats) compared to non-anxious controls. Building on this work, Pittig et al. (2013) found that anxiety disorder patients showed lower HRV at baseline compared to non-anxious controls even when controlling for sex and age. In a recent meta-analytic review, Alvares et al. (2016) found a moderate effect size in the differences in HRV among anxious patients and healthy controls, with anxiety patients displaying reduced HRV. Among individuals with social anxiety disorder, Gaebler et al. (2013) found decreased HRV at baseline and during the processing of emotional faces compared to healthy controls. Notably, reductions in HRV have been associated with emotion processing (Lane et al., 2009), regulation (Visted et al., 2017), and recognition (Quintana et al., 2012). In sum, autonomic inflexibility has implications for individual trajectories and subsequent social interactions, including one’s perception of the interaction and how one behaves during the interaction.

**Interpersonal Autonomic Physiology**
ANS functioning is needed for intrapersonal and interpersonal regulation and could contribute to the formation of social bonds (Geisler et al., 2013; Porges, 2003). Therefore, an investigation of the ANS at both the intra- and interpersonal level of analysis is warranted. For example, during an interaction, peoples’ physiological states can show covariance over time. Interpersonal autonomic physiology (IAP) refers to covariation of autonomic physiological markers between two or more people (Butler, 2011). Extant research on IAP focuses on determining whether covariation of an autonomic marker (e.g., respiratory sinus arrhythmia, skin conductance, or IBI) occurs between two people, and to what extent outcomes are associated with this covariation when it exists (see Palumbo et al., 2017 for a review). Well-established IAP work has focused on dyads with an interaction history (e.g., romantic couples, friends, or teammates; Palumbo et al., 2017). However, interactions between stranger dyads can also be construed as temporal interpersonal emotion systems (TIES) in which emotions, and subsequent changes in ANS activity, are interacting in real-time within and between the individuals (Butler, 2011). For example, electrodermal activity and IBI covariation has been shown among strangers interacting for the first time (Guastello et al., 2006; Scarpa et al., 2018; Silver & Parente, 2004; Strang et al., 2014).

Studies examining IAP refer to complex patterns of covariation as, but not limited to, synchrony, linkage, transmission, concordance, contagion, coupling, cross-over, and co-regulation (Butler, 2011). Each of these terms describes quantitatively and qualitatively distinct patterns of IAP. Given the complex nature of IAP patterns, attempts to model IAP should account for interpersonal and intrapersonal characteristics of physiology, including the frequency of oscillations, damping and amplification of oscillations, and the coupling between partners’ oscillations.
First, physiological signals (e.g., heart rate and respiration) are oscillatory. The oscillations in physiological signals are due to the complex interplay between external perturbations and internal homeostatic processes (Helm, Sbarra, & Ferrer, 2012; Reed et al., 2015). Notably, some physiological signals show different rates of oscillation. Frequency refers to the number of oscillations per unit of time (Reed et al., 2015); patterns can show high frequency or low frequency oscillation.

Second, physiological signals show damping or amplification over time and feedback loops contribute to the stability of the signal. Negative feedback loops (i.e., A leads to B, and subsequently B inhibits A) serve to damp physiological oscillations and stabilize the signal over time (see Figure 2A). Additionally, positive feedback loops (i.e., A leads to B, and subsequently B produces more of A) amplify physiological oscillations and destabilize the signal over time (see Figure 2B). For example, interpersonal situations that initiate regulatory processes both within and between people (e.g., participating in a competitive or cooperative task while getting to know a stranger) are likely to produce patterns in which there is amplification away from baseline as well as damping back to baseline.

To illustrate, imagine a socially anxious person and a non-anxious person going to a job interview. Before the interview, the interviewees find out that they a) will be interviewed at the same time and b) will or will not be offered the position at the end of the interview. In this illustration, the interviewee’s level of social anxiety, emotion regulation, and interpersonal communication with the interviewer could be reflected in each person’s physiological responding (e.g., heart rate or perspiration). If the interview seems to be going well, the interviewee’s physiological response could return back to baseline due to coordinated efforts within the ANS while the opposite would be expected if the interview was going poorly. Further,
these processes could be influenced by the dispositional level of social anxiety of the interviewee (or interviewer). More importantly, however, the high-stakes context sets the backdrop for the interaction, which could exacerbate the stress experienced by individuals with social anxiety.

Third, context is an important factor to consider when interpreting IAP as a social process. IAP has been found in both cooperative and competitive conditions (Chanel et al., 2012; Vanutelli et al., 2017; Vanutelli et al., 2018). For example, it has been shown that IAP is predictive of cooperative success (Behrens et al., 2019; Strang et al., 2014), but other studies have shown that IAP is associated with interpersonal conflict (Levenson & Gottman, 1985). More recently, Danyluck and Page-Gould (2018) found sympathetic synchrony (i.e., covariation of pre-ejection period) among individuals who were primed with dissimilarity compared to individuals who were primed with similarity. In a study utilizing the same dataset as the current study, Danyluck and Page-Gould (2019) found that parasympathetic synchrony and sympathetic synchrony predicted affiliation, but this association was moderated by social context such that affiliation was lower in the competitive contexts. In sum, it is imperative to consider not only the quantitative and qualitative characteristics of the physiological signals themselves, but the context(s) in which they are occurring.

Lastly, as implied from the definition of IAP, dyads’ physiological signals can covary and become coupled over time. For example, an anti-phase pattern occurs when partners’ physiology changes in opposite directions (see Figure 2B). Conversely, an in-phase pattern occurs when changes in partners’ physiology occur in the same direction (see Figure 2A). Thus, there are several types of possible patterns that can be described based on phase and mutually occurring amplification and damping effects (Reed et al., 2013). For example, partners’ physiology can be changing in the opposite direction but amplify together over time (i.e., unstable profile; see
Figure 2B) or partners’ physiology can be changing in the same direction but damping together over time (i.e., stable profile; see Figure 2A).

**Affiliation**

Affiliation is defined as an individual’s desire to “establish, maintain, or restore” relationships with others or groups (Heyns, Veroff, & Atkinson, 1958). Murray (1938) proposed that seeking friendly association with others who resemble one, like one, or whom one likes is a fundamental human desire. In addition to Murray’s contribution, other scholars have argued that the need to belong or affiliate is essential to all domains of human functioning (Baumeister & Leary, 1995; Maslow, 1943). Notably, individuals make affiliative judgments extremely quickly. For example, individuals decide what type of relationship to pursue (e.g., friendship or acquaintance) in the first minutes of an initial encounter (Berg & Clark, 1986). The need to affiliate may be more pronounced in stressful situations. For example, during times of stress, humans often seek out the company of others in order to reduce anxiety and buffer the effects of stressful situations (Cohen & Wills, 1985).

The affiliative process is primarily based on liking or personal attachment and constitutes the first step of relationship building (Hofer & Hagemeyer, 2018). Reciprocal liking, mutual self-disclosure, and similarity are significant determinants of interpersonal attraction across dyadic relationship types (i.e., romantic relationships, same and opposite sex friendships; Campbell et al., 2015). However, the formation of affiliative bonds can be hindered by beliefs about self and fear of rejection (Hofer & Hagemeyer, 2018). In already established relationships, anxiety can be beneficial, to a certain extent, by serving as a signal to repair relationships. However, interactions with strangers are a “gamble” (Brosnan et al., 2017). On the one hand, one can unlock new resources and support by affiliating with strangers. On the other hand, interactions
with strangers involve ongoing judgments about when the environment is safe to share and make the individuals vulnerable to rejection, with the latter factor potentially being a more salient motivator for avoidance exhibited by those with social anxiety (Brosnan et al., 2017). In sum, the affiliative drive among socially anxious individuals could be thwarted by the multiplicative effects of a) fear of rejection, evaluation, and disclosure, b) competitive situations, and c) autonomic dysregulation during the interaction.

The Current Study

Although there is well-established work in the social anxiety, interpersonal autonomic physiology, and affiliation literatures, there is a lack of studies that integrate these processes in a single, empirical investigation. The present study used secondary data to 1) understand the relationship between social anxiety, context, and affiliation and to 2) determine whether interpersonal autonomic physiology is a mediator. This experiment utilized a 2 (Social Interaction, between-subjects: Talking vs. No Talking) × 2 (Interaction Orientation, between-subjects: Cooperative vs. Competitive) dyadic design in which same-sex, same ethnicity partners completed a knot tying task. In accordance with the VSA conceptual model (Figure 1), social anxiety (i.e., vulnerability) was measured before the task. Autonomic physiology (i.e., the adaptive process) was measured via electrocardiogram continuously throughout the task for both partners. For the present study, IBI, which is a continuous, second-by-second measure of the time between heartbeats, was the physiological measure of interest due to its sensitivity to both SNS and PNS activity. After completing the task, all participants reported perceived affiliation.

For the analyses, the rties package (Butler & Barnard, 2019) was used to model the covariation of IBI over time, using a coupled oscillator (CO) model that captured both individual and dyad level physiological dynamics over the entirety of the task (Helm et al., 2012). Utilizing
the parameters from the CO, dynamic IAP profiles (see Figure 2 for examples) were generated using latent profile analysis. Finally, Bayesian statistics was utilized for testing the paths in the proposed model (Figure 1).

**Research Questions and Hypotheses**

In combination with key findings from the literature review above, the following research questions are based on the proposed model (Figure 1). Specifically, the research questions (RQs) and corresponding hypotheses are arranged by model path.

*Path A and Path B*

Given that socially anxious individuals are prone to avoiding conversations that require personal disclosure, especially to strangers, it stands to reason that socially anxious individuals might find conditions in which there is competition and conversation to be stressful. For instance, when socially anxious individuals partake in a conversation, there may be more opportunities for the socially anxious individual to “pull” the other person into the self-perpetuating cycle of social anxiety and to show behavioral manifestations of anxiety. Furthermore, the stress in a competitive-talking context should be reflected in both persons’ ANS responses to the interaction. Stated formally:

**RQ1a:** Does condition (talking/not talking and cooperative/competitive) predict IAP profile?

**H1a:** There are many different ways the two manipulations could affect IAP profile membership. For example, on the one hand, in the talking/competitive condition, an unstable dynamic profile could emerge to the extent that completion of the task and disclosure are incongruent (i.e., demanding) goals. However, on the other hand, this same condition could lead to a stable dynamic profile due to
the mutual experiences of completing the task and the give and take of
conversation. In the absence of prior research and lack of apriori hypotheses, this
RQ was tackled in a somewhat exploratory spirit.

RQ1b: Does condition (talking/not talking and cooperative/competitive) interact with
social anxiety to predict IAP profile?

H1b: If both partners are high on social anxiety, then an unstable pattern will be
predicted, especially for those in the talking-competitive condition.

H1b: If partners show a greater discrepancy in social anxiety, then an unstable
pattern will be predicted, especially for those in the talking-competitive condition.

Path F and Path G

There is a potential reciprocal relationship between the ongoing process of adaptation
(i.e., IAP) and perception of affiliation (see Paths F and G in Figure 1) such that an individual’s
perception of affiliation should change as a function of his or her accumulated interpersonal
exchanges and intrapersonal regulatory processes (Path F). Simultaneously, perception of
affiliation will be related to how individuals approach and adapt to various difficulties and
transitions during the interaction (Path G). More specifically, the interpersonal cycle of social
anxiety could be illustrated in patterns of IAP such that a socially anxious person could “pull”
their partner into an unstable pattern of physiology. Conversely, the interpersonal cycle could
be broken by the non-socially anxious person pulling the socially anxious person into a stable
pattern of physiology, which may better predict perceptions of affiliation. Stated formally:

RQ2: Does condition interact with social anxiety to predict affiliation?

H2a: If both partners are high on social anxiety, then lower affiliation will be
predicted, especially in the talking-competitive condition.
H2b: If partners show a greater discrepancy in social anxiety, then lower affiliation will be predicted, especially for those in the talking-competitive condition.

RQ3a: Does IAP predict affiliation?

H3a: Stable IAP profiles will predict higher affiliation while unstable IAP profiles will predict lower affiliation.

RQ3b: Does affiliation predict IAP?

H3b: Higher levels of affiliation will predict a stable profile while lower levels of affiliation will predict an unstable profile.

RQ4: Does IAP mediate the relationship between condition and affiliation and/or does affiliation mediate the relationship between condition and IAP?

Given the lack of prior research, I am not making any *a priori* hypotheses for this RQ.

*Exploratory Analysis*

Given that perceived similarity is a determinant of interpersonal attraction and was included in the post-task questionnaires in this dataset, an exploratory analysis (EA) will determine if IAP was a predictor of perceived similarity to partner.

EA1: Does IAP predict perceived similarity to partner?

**Method**

**Participants and Procedure**

*Participants*

This dataset comes from a larger study examining intragroup interactions at the University of Toronto where introductory psychology students and community members were
recruited to complete a 2-hour study. Study procedures and materials were approved by the
University of Toronto Institutional Review Board. Participants included in this study provided
written consent prior to engaging in study procedures. Participants were paired with a same-sex,
same ethnicity partner before coming in to complete the experiment. The sample (N = 116) was
approximately 75% female and the mean age was 20.5 years (SD_age = 5.64). The sample was
relatively diverse: 40% East Asian, 32% White, 11% South Asian, 5% Southeast Asian, 4%
Middle Eastern, 4% Black, 3% West Indian, 1% multi-ethnic, and 1% Hispanic. Additionally,
62% of the sample reported making less than $5,000 per year. Regarding compensation,
participants had the option to receive course credit, $20.00, or a combination of course credit and
money.

Design

Participant pairs were randomly assigned to condition in 2 (Social Interaction, between-
subjects: Talking vs. No Talking) × 2 (Interaction Orientation, between-subjects: Cooperative vs.
Competitive) between-dyad design.

Experimental Procedure

After providing consent and completing pre-task questionnaires, participants were
connected to the physiological recording equipment. A physiological baseline recording was
collected for five minutes before beginning the task. After the baseline recording, participants
were instructed to complete a knot-tying task using strings attached to their chairs. Each
participant received a three-foot string and were instructed to use their dominant hand to tie as
many knots as possible during a five-minute period. The degree of sociality of the task was
manipulated: Participants were assigned to get to know each other while completing the task
(Talking Condition) or to remain silent (No Talking Condition). The type of social interaction
was manipulated: Participants were told they would receive points win an Amazon gift card for each knot that the dyad tied collaboratively (Cooperative Condition) or for each knot more that they tied relative to their partner (Competitive Condition). Based on condition, research assistants read a different framing script before starting the task, which are described in detail below.

**Talking-cooperative.** Pairs in the taking-cooperative condition were given the following instructions:

> We want you to get to know your partner while working toward a collaborative goal. You will both receive one long string in your dominant hand. We want you to tie as many knots as possible in five minutes on one long string using one hand. This is a fun party-game, designed to encourage social affiliation and cooperation. You should be trying to get to know each other at the same time as completing this task so feel free to ask each other personal questions and at the same time try to cooperate with each other on this task. The more knots you can tie as a team, the more points you will each receive. The team with the highest points will be entered into a draw to receive two $50.00 gift cards at Amazon.ca.

**Talking-competitive.** Pairs in the talking-competitive condition were given the following instructions:

> We want you to get to know your partner while competing for points/rewards. You will both receive one long string in your dominant hand. We want you to tie as many knots as possible in five minutes on one long string using one hand. This is a fun game, designed to encourage social affiliation and competition. You are competing against each other for a small reward, but you should try to get to know each other at the same time so feel free
to socialize and to ask each other personal questions. The more knots you can tie as an individual, the more points you will receive. Whoever has the most points will be entered into a draw to receive a $50.00 gift card at Amazon.ca.

**No talking-cooperative.** Pairs in the talking-cooperative condition were given the same instructions as the talking-cooperative participants, but they were instructed not to talk: “Do not socialize, do not talk. Just work on the task. The more knots you can tie as a team, the more points you will each receive.”

**No talking-competitive.** Pairs in the no talking-competitive condition were given the same instructions as the no talking-cooperative condition, but they were instructed not to talk to each other: “Do not socialize, do not talk. Just work on the task. You are competing against each other.”

*Physiological Data Acquisition and Processing*

Cardiovascular data was measured by electrocardiogram (ECG) for all participants continuously throughout the interaction. ECG was recorded with electrodes in the modified Lead II placement and sent to a computer via Biopac ECG100C Module and MP150 amplifier (Biopac Systems, Inc., Goleta, CA). To extract the interbeat interval (i.e., IBI; the time between subsequent R waves or the time to complete one cardiac cycle in milliseconds), the ECG data was scored with Acknowledge version 4.4 (Biopac Systems, Inc., Goleta, California). The IBI data was segmented into 2-second intervals. Next, the mean over each 2-second interval was calculated for the full five-minute conversation, resulting in 150 observations for each participant.

*Self-Report Measures*
For descriptive statistics and zero-order correlations for the self-report measures below, see Table 1.

**Social Anxiety**

General social anxiety was measured with a 9-item questionnaire (e.g., “I feel anxious in social situations”; “I often feel nervous even in casual get togethers”) that was rated on a 5-point Likert scale (1 = *not at all* to 5 = *extremely*). Participants completed this questionnaire before starting the task. Because the social anxiety items had sufficient internal reliability ($\alpha = .87$), a composite (sum) score was calculated for each person ($M = 41.57$, $SD = 12.92$).

**Affiliation**

Perceived affiliation with partner was measured with a 24-item questionnaire (e.g., “How much do you like your partner?”; “How sociable was your partner during the interaction?”) that was rated on a Likert scale (1 = *not at all* to 7 = *very*). Participants completed this questionnaire after the task. Given that this measure was developed for this study by pulling items from a variety of sources, the internal structure was unknown. To explore whether this scale assessed one underlying construct or multiple ones, an exploratory factor analysis (EFA) was completed. Five distinct factors were found. The factors are described briefly here. See Appendix A for more detailed information. Factor 1 (i.e., liking and future friendship) was comprised of 8 items ($\alpha = .84$). Factor 2 (i.e., comfort or enjoyment during the interaction) was comprised of 5 items ($\alpha = .90$). Factor 3 (i.e., personal qualities of each partner) was comprised of 4 items ($\alpha = .17$). Factor 4 (i.e., involvement in the interaction) was comprised of 3 items ($\alpha = .86$). Factor 5 (i.e., perception of trust) was comprised of only 2 items ($\alpha = .85$). Each subscale was used as an outcome for the research questions referencing affiliation, however factor 3 was omitted given the alpha below 0.50.
**Perceived Similarity**

Perceived similarity to partner was measured after the task using a 5-item questionnaire (e.g., “My partner and I are very similar”; “My partner and I share a lot in common”) that was rated on a Likert scale (1 = not at all to 7 = very). The mean was 4.45 ($SD = .99$) and the alpha was .92. This scale was used in exploratory analyses only.

**Analytic Plan**

**Coupled Oscillator Model**

The *rties* package (Butler & Barnard, 2019) provides models for exploring temporal processes in dyadic systems. The models the package supports require distinguishable dyads. Given that the dyads in this study were indistinguishable in terms of sex or ethnicity, social anxiety was used as the distinguisher. To create the distinguishing variable, each participant’s score was compared to their partner’s score on the social anxiety scale. The partner with a higher level of social anxiety was assigned a 1 and the partner with a lower level of social anxiety was assigned a 0.

The couple oscillator (CO) model in *rties* estimates both the individuals’ trajectories and cross-partner covariation on physiological signals. In accordance with CO modeling, all data were linearly detrended and the intercept was removed (Boker & Laurenceau, 2006). The *rties* package removes linear trends by estimating the residuals from the person’s IBI as predicted from time and using those in subsequent steps.

The *rties* CO model is built by estimating a series of derivatives from the data. To begin building the CO model, delta, tau, and embeds values were specified. Specifically, delta refers to the inter-observation interval. The delta was set to 1, therefore every observation was utilized for fitting. Tau refers to the number of points to include when estimating the first derivative, which
is the mean of two adjacent slopes across that number of time points on either side of time (t). In essence, tau works as a smoother in the model. Embed is related to the number of derivatives desired (i.e., n + 1). Since the second derivative (i.e., the difference between the two slopes with respect to time as specified by tau) is needed, the minimum embed was 3. Based on the specified delta (i.e., 1), tau (i.e., vector of 2 and 3), embed (i.e., vector of 3 and 4) values, the estimate derivatives function fitted a CO to each dyad and returned a list with the maximal R² (i.e., how well the model fits the dyad), the tau and embed value that resulted in the maximal R², and the period of oscillation associated with those tau and embed values. This information was used to determine tau and embed values that fit well for most dyads and showed the range of oscillation appropriate for IBI. The mean oscillation period for the data was 30 seconds. Finally, a visual inspection of model fit for each dyad was conducted (see Figure 3). The CO model appeared to be a good fit for most dyads.

Next, four parameters were generated for each partner using the CO model: 1) a person’s own IBI time series, which is related to frequency of oscillations, 2) the first derivative of the person’s IBI time series, which indicates damping/amplification, 3) a person’s partner’s IBI time series, which indicates coupling in regards to frequency, and 4) a person’s partner’s first derivative of their IBI time series, which indicates coupling regarding damping/amplification. Therefore, a total of 8 parameters were generated for each dyad. These 8 parameters were written into a separate data frame and used in the later steps of this analysis. Although rties allows for the comparison of a coupled (i.e., assuming mutual influence on IBI) and uncoupled model (i.e., no mutual influence on IBI), only the coupled model was considered given the focus on interpersonal processes.
Latent Profile Analysis

Unlike linear models, one cannot examine a parameter from the CO in isolation and make conclusions about the dynamic pattern; the parameters from the CO work as a set to determine the dynamic trajectory for each partner over time. Thus, for the next step of modeling, the set of 8 parameters were utilized as input to a latent profile analysis (LPA) that grouped dyads based on dynamics over the course of the task.

The rties package requires the user to specify the number of profiles to generate. First, a 2-profile solution was compared to a 3-profile solution. To determine the total number of acceptable profiles, three criteria were used. First, the interpretability of meaningful dynamics based on theory was evaluated (e.g., do the dynamics represented in each profile reflect what would be expected given past research or theory?). Second, the number of dyads assigned to each profile was examined. To ensure robust profiles, there should be an even distribution of dyads across profiles (i.e., no less than 10% of the total dyads in the smallest profile). Lastly, the degree of separation and overlap of the profiles was examined. For example, Figure 4 shows the 3-profile solution in which the green profile had significant overlap with the blue profile. Although the blue profile contained more than 10% of the total dyads, the blue profile was diffuse and showed poor separation from the green and red profiles, which were clustered tightly. Given this poor separation, a 2-profile solution was used for the LPA. Finally, rties provided predicted trajectories for each profile (see Figure 2 for final profiles). Figure 2A shows a damping, stable pattern (n = 40 dyads), while Figure 2B shows an amplifying, unstable pattern (n = 18 dyads). Profile membership was written as a variable in the data frame to be used in subsequent models.
Bayesian Modeling

To test the paths proposed in the conceptual model (Figure 1), the statistical analysis software R was used (version 3.5.1; R Core Team, 2018). Specifically, the statistical package \textit{brms} was used to estimate the Bayesian models (Bürkner, 2017). Bayesian modeling is an alternative to the Null-Hypothesis Significance Test (NHST) for statistical inference. The confidence intervals (CIs) used in NHST imply that if one was to sample from the population 100 times and generate 100 95% CIs, 95 of those CIs would contain the population mean and 5 would not; there is no way to know whether the interval from a particular sample contained the population mean or not. In contrast, Bayesian estimation models the uncertainty of the parameters by generating the posterior distribution and providing a credible interval (CI), also known as a highest density interval (HDI). Put simply, the HDI allows researchers to estimate the actual probability that the population parameter value falls into the given range, given the data and the model. The width of the HDI reflects the degree of uncertainty of beliefs. If the HDI is wide, beliefs are uncertain. For example, a wide HDI reflects uncertainty of beliefs (e.g., if the HDI for a predictor contains 0, it is not a likely predictor of the outcome). If the HDI is narrow, beliefs are relatively certain (e.g., if the HDI for a predictor ranges from .10 to 20, it is a likely predictor of the outcome) (Kruschke & Liddell, 2018). Lastly, Bayesian methods allow for the inclusion of prior information (e.g., distributions of regression coefficients), which increases efficiency (i.e., limits the sampling range when building the posterior distribution) and improves quality of estimates (Yuan & MacKinnon, 2009).

Models for Hypothesis Testing

In order to determine whether sex and/or ethnicity were needed as control variables, an interaction between sex and condition and ethnicity and condition as predictors of profile
membership was conducted. The results showed no significant interaction between condition and sex or condition and ethnicity. Therefore, sex and ethnicity were not used as control variables in the models.

For each model, weakly informative prior distributions for the parameters were specified. For the outcome of affiliation (i.e., each factor from the EFA), the form of the distribution (e.g., normal) was specified with the mean and standard deviation providing the central tendency and degree of dispersion. The independent variable and mediator were constrained by being multinominal and binary, respectively. The brms package handles the categorical variables with dummy coding. In this case, uninformative default priors were used for the predictor and mediator. In brms, the user can specify a family link (e.g., using a “bernoulli” link for binary outcomes and “gaussian” or “skew_normal” link for continuous outcomes). Therefore, the family link was changed based on the type of outcome for each model.

The next step is Markov Chain Monte Carlo (MCMC) Estimation. After the priors were specified, the model was estimated using chains (4), iterations (2000), and cores (1). Convergence of the models was confirmed using R-hat values (i.e., should be less than 1.1). There were no convergence issues, however the number of chains, iterations, and cores was increased (i.e., to 5, 5000, and 10, respectively) to better estimate the posterior distribution and help with speed of the analyses. 95% highest density intervals (HDIs) were provided for all parameters in the output. For a predictor variable, the variable is an unlikely predictor of the outcome if the 95% HDI contains 0.

Regarding mediation models, I utilized the mediation function provided in the R package sjstats (Lüdecke, 2020) in conjunction with brms (Bürkner, 2017). The mediation function provided a data frame with estimates of the direct effect, indirect effect, and total effect along
with the corresponding 90% HDIs. The proportion mediated was automatically calculated by the function and HDIs were provided. The main goal of these steps was to determine if the indirect effect, or the amount of mediation, was non-zero and whether the proportion mediated was meaningful (Baron & Kenny, 1986). A large drop in the total effect suggests that much of the effect travels through the tested mediator, while a small drop suggests only partial mediation through the tested mediator.

**Results**

**Missing Data**

There were 8 dyads with missing physiological data who were not included in the analyses ($n_{final} = 58$ dyads). After removing these 8 dyads, there was no missing data on participants’ IBI measure. Given that there was less than 1% missingness on all other variables utilized for the analysis, listwise deletion was used.

**Creating the Social Anxiety Variables for Analysis**

Given that social anxiety was used as the distinguishing variable (i.e., a categorical variable; 0 for the person who reported lower anxiety and 1 for the person who reported higher anxiety in the dyad) to create the dynamic profiles, social anxiety needs to be included in the models for hypothesis testing in order to explain variance in the outcome. However, there are two ways dyadic social anxiety can be conceptualized: As the sum of or as the discrepancy between the social anxiety scores for individuals in each dyad. To examine the sum of social anxiety for dyads, each person’s score on the 9-item social anxiety scale was added to their partner’s score to create a dyad total. Second, to explore the discrepancy between individuals in dyads, a difference score was created by subtracting each person’s score from their partner’s
score, then the absolute value of this score was taken. Therefore, the results provided below take into account total anxiety and relative difference in anxiety.

Results by Research Question

RQ1a: Does condition predict IAP profile?

Condition was not a probable predictor of IAP profile (Estimate = 0.08, 95% HDI [-0.28, 0.44]).

RQ1b: Does condition (talking/not talking and cooperative/competitive) interact with social anxiety to predict IAP profile?

The interaction between total social anxiety and condition was not probable (Estimate = 0.05, HDI [0.00, 0.09]). There were no main effects of total social anxiety (Estimate = -0.14, 95% HDI [-0.29, 0.01]) or condition (Estimate = -1.86, HDI [-3.83, 0.08]) on IAP profile.

The interaction between difference in social anxiety and condition was not probable (Estimate = 0.06, 95% HDI [-0.17, 0.29]). There were no main effects of difference in social anxiety (Estimate = 0.01, 95% HDI [-0.52, 0.57]) or condition (Estimate = -0.07, 95% HDI [0.88, 0.74]) on IAP profile.

RQ2: Does condition interact with social anxiety to predict affiliation?

The interaction between a) relative social anxiety and condition and b) total social anxiety and condition was not probable (all HDIs contained 0). There were no main effects of relative social anxiety or total social anxiety on Factor 1 (Liking/Future friendship), Factor 2 (Comfort/Enjoyment), Factor 4 (Involvement), or Factor 5 (Trust).

Given that the predicted interaction was not probable, social anxiety was removed from the model to examine the effect of the two manipulations on each affiliation factor. Regarding Factor 2 (Comfort/Enjoyment), there was a main effect of talking such that comfort/enjoyment
was higher in the talking condition compared to the no talking condition (Estimate = 0.41, 95% HDI [0.04, 0.07]). For Factor 4 (Involvement), there was a main effect of talking such that involvement was higher in the talking condition compared to the no talking condition (Estimate = 1.07, 95% HDI [0.40, 1.73]). Regarding Factor 5 (Trust), there was a main effect of competition such that trust was lower in the compete condition compared to the cooperative condition (Estimate = -0.46, 95% HDI [-0.92, -0.01]).

**RQ3a: Does IAP predict affiliation?**

IAP was not a probable predictor of Factor 1, Factor 2, Factor 4, or Factor 5 (all HDIs contained 0).

**RQ3b: Does affiliation predict IAP?**

Factor 1 (Liking/Future Friendship) was not a likely predictor of IAP profile (Estimate = 0.02, HDI [-0.37, 0.39]). Factor 2 (Comfort/Enjoyment) was not a likely predictor of IAP profile (Estimate = -0.09, 95% HDI [-0.51, 0.30]). Factor 4 (Involvement) was not a likely predictor of IAP (Estimate = -0.02, 95% HDI [-0.28, 0.24]). Factor 5 (Trust) was not a likely predictor of IAP (Estimate = -0.14, 95% HDI [-0.51, 0.22]).

**RQ4: Does IAP mediate the relationship between condition and affiliation and/or does affiliation mediate the relationship between condition and IAP?**

IAP was not a likely mediator of the relationship between condition and any of the affiliation subfactors. All 95% HDIs for the indirect effects contained 0.

**Exploratory Analysis**

*Does IAP predict perceived similarity to partner?*
IAP was a likely predictor of perceived similarity to partner (Estimate = -0.35, 95% HDI [-0.67, -0.02]) such that perceived similarity was lower in profile 2 (i.e., damping, stable profile) than in profile 1.

**Supplementary Analyses**

In order to address the issue of multicollinearity stemming from the use of social anxiety as the distinguisher and as a predictor, a distinguisher was created by randomly assigning a one or a zero to each person in the dyad. The coupled oscillator and latent profile analysis steps were repeated to generate profiles based on the random distinguisher. As expected, the profiles were not qualitatively different than the profiles generated using social anxiety as the distinguisher. Research questions 1-4 were then re-analyzed using the random distinguisher. The findings mirrored the results presented above.

**Discussion**

This study investigated whether IAP patterns mediated the relationship between stressful events and affiliation-related outcomes among socially anxious and non-socially anxious strangers interacting for the first time. The results showed higher comfort/enjoyment and involvement in the talking conditions versus the no talking conditions. Furthermore, there was lower trust in the competing condition versus the cooperative condition. Overall, these findings support past work showing that talking is crucial to relationship formation (Campbell et al., 2015) and that competition breeds mutual negative attitudes, including distrust (Deutsch, 2011). Additionally, the exploratory analysis revealed that IAP was a likely predictor of perceived similarity to partner. Specifically, similarity was lower in the damping, stable profile compared to the amplifying, unstable profile. Based on the *apriori* hypotheses for the research questions examining the relationship between IAP profile and the affiliation subscales (i.e., stable profiles
were hypothesized to predict more affiliation), this finding seems inconsistent with what would be expected. Given that perceived similarity is an important determinant of interpersonal attraction (Campbell et al., 2015), future work should focus on the role of IAP specific to judgments of similarity.

Important considerations for physiology include potential sex differences in autonomic physiological responses. For example, studies have shown no vagal tone differences between high and low socially anxious women (Mauss et al., 2003; Mauss et al., 2004) and reduced HRV at baseline and in response to a stressor among women but not men who are socially anxious (Grossman et al., 2001). Although sex did not differentially predict IAP profile in this study, these conflicting results could guide future research. Furthermore, given that a) socially anxious individuals are prone to emotion suppression (Kashdan & Steger, 2006) and b) emotion suppression is related to changes in the ANS and is associated with relationship formation (Butler et al. 2003), measures of emotion suppression could be crucial in unpacking the role of physiology in this sample. Furthermore, given that the unstable IAP profile predicted more perceived similarity to partner compared to the stable IAP profile, it could be that unstable patterns of IAP are related to ongoing engagement with the environment, instead of being indicative of mutual dysfunction. In contrast, the stable IAP profile could be indicative of environmental disengagement, rather than effective interpersonal ANS regulation. More work is needed to determine what type of IAP patterns differentially predict social outcomes.

In reference to social anxiety, socially anxious individuals are likely to engage in post-event rumination (i.e., critical analysis of performance in a social event after it occurs; Kashdan & Roberts, 2007). Post-event rumination may have implications for affiliation, especially when measured after an interaction. As this was a non-clinical sample, the level of social anxiety may
have not been enough to manifest behaviorally or physiologically during the interaction. Brosnan et al. (2017) posit that anxiety becomes pathological when “the system goes into overdrive” and prohibits the establishment of stable relationships. The amount of social anxiety in this sample may not have crossed this threshold. Most importantly, it could be that low levels of situational social anxiety may not detrimental to relationship formation.

Notably, the data were not designed for the purpose of the current study. Given that affiliation was only measured once and after the task, no conclusions about the reciprocal nature of IAP and affiliation can be made. These results should be interpreted with caution, as there were only 18 dyads in the unstable profile versus 40 dyads in the stable profile; this power limitation could be hindering the detection of possible effects in this sample. For future studies examining similar constructs, affiliation should be measured during the task and a confirmatory factor analysis should be completed on the 24-item affiliation scale, if possible. Despite the aforementioned limitations, this study represents the first step in understanding the role of IAP in the affiliation process during initial interactions among strangers with differing levels of social anxiety.
Table 1

Means, Standard Deviations, and Correlations with Confidence Intervals for Self-Report Measures

<table>
<thead>
<tr>
<th>Variable</th>
<th>M</th>
<th>SD</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Total Social Anxiety</td>
<td>21.53</td>
<td>7.30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Perceived Similarity</td>
<td>4.45</td>
<td>0.99</td>
<td>-.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[-.21, .17]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Liking/Friendship</td>
<td>4.42</td>
<td>1.10</td>
<td>-.07</td>
<td>.75**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[-.26, .12]</td>
<td>[.65, .82]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Comfort/Enjoyment</td>
<td>4.98</td>
<td>0.85</td>
<td>-.09</td>
<td>.65**</td>
<td>.70**</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[-.27, .10]</td>
<td>[.52, .74]</td>
<td>[.59, .78]</td>
<td></td>
</tr>
<tr>
<td>5. Involvement</td>
<td>4.72</td>
<td>1.56</td>
<td>.01</td>
<td>.54**</td>
<td>.69**</td>
<td>.70**</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[-.18, .19]</td>
<td>[.40, .66]</td>
<td>[.58, .78]</td>
<td>[.58, .78]</td>
</tr>
<tr>
<td>6. Trust</td>
<td>4.32</td>
<td>1.13</td>
<td>-.04</td>
<td>.60**</td>
<td>.64**</td>
<td>.58**</td>
<td>.49**</td>
</tr>
</tbody>
</table>

*Note. M and SD are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2014). * indicates $p < .05$. ** indicates $p < .01$. 
Figure 1

The Vulnerability-Stress-Adaptation Based Conceptual Model
Figure 2

Dynamic Trajectories of IBI Across the 2-Profile Solution

A

Note. 2A. Profile 2 is defined by damping on behalf of both partners with an in-phase pattern, which can be referred to as a damping, stable profile.

2B. Profile 1 is characterized by co-amplification with a drift phase pattern, moving from in-phase to anti-phase. This pattern depicts an amplifying, unstable profile.
**Figure 3**

*Model Fit Visualization*

A

![Figure 3A](image)

*B

![Figure 3B](image)

*Note.* 3A. Coupled oscillator depicting a good fit for dyad 86.

3B. Coupled oscillator depicting a poor fit for dyad 8.
Figure 4

*Clustering Visualization from Latent Profile Analysis*

*Note.* Depicts proper separation of the red and green profiles with a poorly separated, diffuse blue profile.
# APPENDIX A

Exploratory Factor Analysis of Perceived Affiliation Scale

<table>
<thead>
<tr>
<th>Items</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>How much do you like your partner?</td>
<td>0.52</td>
<td>0.49</td>
<td>0.40</td>
<td>0.32</td>
<td>0.07</td>
<td>Liking and Future Friendship</td>
</tr>
<tr>
<td>How likely is it that you would become friends with your partner?</td>
<td>0.86</td>
<td>0.16</td>
<td>0.19</td>
<td>0.23</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>How much do you and your partner have in common?</td>
<td>0.64</td>
<td>0.29</td>
<td>0.11</td>
<td>0.14</td>
<td>0.21</td>
<td></td>
</tr>
<tr>
<td>How much would you want to interact with your partner in the future?</td>
<td>0.78</td>
<td>0.25</td>
<td>0.10</td>
<td>0.24</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td>How much do you think your partner likes you?</td>
<td>0.55</td>
<td>0.40</td>
<td>0.37</td>
<td>0.23</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>How likely does your partner think it is that the two of you would become friends?</td>
<td>0.88</td>
<td>0.07</td>
<td>0.19</td>
<td>0.15</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>How much do you think your partner thinks you have in common?</td>
<td>0.66</td>
<td>0.33</td>
<td>0.15</td>
<td>0.15</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td>How much do you think your partner would want to interact with you in the future?</td>
<td>0.83</td>
<td>0.18</td>
<td>0.20</td>
<td>0.09</td>
<td>0.23</td>
<td></td>
</tr>
<tr>
<td>How comfortable do you feel with your partner?</td>
<td>0.25</td>
<td>0.71</td>
<td>0.30</td>
<td>0.22</td>
<td>0.18</td>
<td>Comfort and Enjoyment</td>
</tr>
<tr>
<td>How much did you enjoy interacting with your partner?</td>
<td>0.42</td>
<td>0.64</td>
<td>0.25</td>
<td>0.32</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>How poised was your partner during the interaction?</td>
<td>0.13</td>
<td>0.59</td>
<td>0.21</td>
<td>0.21</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td>How comfortable do you think your partner feels with you?</td>
<td>0.49</td>
<td>0.58</td>
<td>0.21</td>
<td>0.12</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>How much do you think your partner enjoyed interacting with you?</td>
<td>0.47</td>
<td>0.56</td>
<td>0.31</td>
<td>0.14</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>How selfish is your partner?</td>
<td>-0.09</td>
<td>-0.23</td>
<td>-0.55</td>
<td>-0.21</td>
<td>-0.12</td>
<td>Personal Qualities</td>
</tr>
<tr>
<td>How genuine is your partner?</td>
<td>0.07</td>
<td>0.33</td>
<td>0.82</td>
<td>0.17</td>
<td>0.18</td>
<td>Qualities</td>
</tr>
<tr>
<td>How helpful is your partner?</td>
<td>0.31</td>
<td>0.22</td>
<td>0.57</td>
<td>0.08</td>
<td>0.17</td>
<td></td>
</tr>
<tr>
<td>How genuine does your partner think you are?</td>
<td>0.26</td>
<td>0.13</td>
<td>0.73</td>
<td>0.13</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>How sociable was your partner during the interaction?</td>
<td>0.29</td>
<td>0.34</td>
<td>0.24</td>
<td>0.80</td>
<td>0.13</td>
<td>Involvement</td>
</tr>
<tr>
<td>How involved was your partner during the interaction?</td>
<td>0.25</td>
<td>0.38</td>
<td>0.29</td>
<td>0.62</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>How much during the interaction did your partner elaborate on his or her thoughts about the topic of conversation?</td>
<td>0.43</td>
<td>0.21</td>
<td>0.24</td>
<td>0.53</td>
<td>0.01</td>
<td>Interaction</td>
</tr>
<tr>
<td>How much do you trust your partner?</td>
<td>0.31</td>
<td>0.23</td>
<td>0.35</td>
<td>0.11</td>
<td>0.84</td>
<td>Trust</td>
</tr>
<tr>
<td>How much does your partner trust you?</td>
<td>0.45</td>
<td>0.17</td>
<td>0.19</td>
<td>0.13</td>
<td>0.57</td>
<td></td>
</tr>
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</table>

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