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Physiological Coregulation Intervention Over Video Call in New Relational Dyads

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Physiological Coregulation Intervention Over Video Call in New Relational Dyads

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Abstract

Physiological linkage, the degree to which physiological behavior of one partner in a relationship is related to the physiological behavior of the other partner, is a well-documented process. Electrodermal activity (EDA) and heart rate variability (HRV) are two physiological measures for which physiological linkage has been observed (Timmons, et al., 2015). A more specific term, coregulation, has been proposed to specify a process of mutual physiological regulation within a relational dyad towards a homeostatic set point (Butler & Randall, 2013). While an important construct, there is a present lack of intervention studies seeking to increase the capacity for coregulation in relational dyads. Furthermore, there has been a recent massive increase in video call technologies, in response to the global Covid-19 pandemic. Therefore, this author conducted an intervention study over video call that sought to observe if: a) physiological linkage occurs between relational dyads interfacing via video call and b) the relational capacity for coregulation can be increased over time via a relational play intervention carried out over three weeks on video call. Results showed partial support for hypothesis one, partnered participants' HRV was significantly correlated at baseline and during the stress-inducing exercise, regardless of group assignment. Results supported the null hypothesis for hypothesis two, demonstrating that the intervention dyads did not exhibit a higher degree of coregulation during posttest compared to the control dyads. However, all dyads demonstrated a return to homeostatic baseline after a stressor at both pretest and posttest, suggesting that relational dyads can effectively coregulate in response to a stressor while interacting over video call. Implications will be discussed below.

Keywords: coregulation, physiological linkage, video call, videoconference, intervention study

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Physiological Coregulation Intervention Over Video Call in New Relational Dyads

The study of physiological linkage between relational partners has been the subject of research since the 1950's (Di Mascio et al., 1955). Physiological linkage means that the physiological response of one relational partner is predictive of the physiological response of their fellow participant. Timmons and colleagues (2015) summarized the variety of physiological measures used by researchers to assess physiological linkage. These measures include: heart rate (Ferrer & Helm, 2013; Helm et al., 2014; McAssey et al., 2013), pulse (Chatel-Goldman et al., 2014), electrodermal activity (Chatel-Goldman et al., 2014), cortisol (Berg & Wynne-Edwards, 2002; Laurent & Powers, 2007; Liu et al., 2013; Papp et al., 2013; D. E. Saxbe et al., 2014; D. Saxbe & Repetti, 2010; J. E. Schreiber et al., 2006; Storey et al., 2000), blood pressure (Reed et al., 2013), neural activity measured via fMRI (Atzil et al., 2012), respiration (Ferrer & Helm, 2013; Helm et al., 2012; McAssey et al., 2013) respiratory sinus arrythmia (Helm et al., 2014), and thoracic impedance (McAssey et al., 2013).

While physiological linkage has been the predominant term used to describe the way each partner in the relational dyad influences the physiological experience of the other partner, numerous terms have been used. At times this process has been coined physiological linkage, synchrony, or coregulation (Timmons et al., 2015), and more recently the term interactive contingency has been used as a broader term to connote the process of any interaction between individual and dyad behavior, whether that be facial expression, physiology or affective responding (Beebe & Lachmann, 2020). The multiplicity of the terms used suggests the degree of complexity inherent to studying the physiological and emotional transfer within relational dyads (Butler & Randall, 2013; Timmons et al., 2015).

Fogel (1992) used the term “co-regulation” in his connection between dynamic systems theory and social interaction. He described it as a social process by which, “individual action is linked to information that is jointly created by the movements and spatial patterning of both partners” (p. 516). The jointly created actions of the relational dyad is greater than the aggregate of each individual’s action. The relational process of coregulation is a dynamic interchange of behavior as each individual simultaneously influences, and is influenced by, the behavior of the other and the behavior of the overall system. Beebe and Lachmann (1998) provide a helpful clarification in their discussion of self and mutual recognition. They note that researchers frequently highlight either the process of self-recognition or mutual recognition. Instead, Beebe and Lachmann say that these are co-occurring processes, and that one cannot be separated from the other. Schreiber et al. (2021) identified a similar phenomenon, instead using the terms “contrarian coregulation” to identify misalignments with a partner’s physiology and “dependent coregulation” to identify alignments with a partner’s physiology.

Following in Fogel’s lead, Butler (2011), and later Butler and Randall (2013), began to expand the use of “coregulation” to describe a process of homeostatic physiological and affective stability within a relationship, while maintaining Fogel’s expressed importance of “bidirectional linkage” between partners. In discussing a regulatory and homeostatic process, Butler and Randall adapt the conversation that normally surrounds research on self-regulation to fit into the relational framework of co-occurring self and mutual recognition.

Butler and Randall’s definition of coregulation also differs from some others in that they define coregulation as a relational occurrence that is predominately beneficial to the dyad. They define coregulation in the following manner: “the bidirectional linkage of oscillating emotional channels (e.g., experience, behavior, physiology) between partners which contributes to emotional and physiological stability" (p. 213). Their specific focus is the degree to which coregulation leads to "emotional and physiological stability" across the system of the relational dyad.

In contrast to coregulating relationships which pull each partner towards a baseline of greater stability, there are also relationships which cause the inverse. As was observed by Levenson and Gottman (1983), many couples in their study became trapped in negative conflict cycles. In this case each partner's behavior becomes rigid and predictable—leading to the observation of strong behavioral influence across the partnership, and thereby physiological linkage—and yet the relational outcome was negative. A similar negative relational cycle called co-rumination is a repetitive process in which two or more interdependent people continue to discuss a problem with no plan to solve it (Gross & Medina-DeVilliers, 2020). This negative cycle can increase threat perception and response (Parkinson & Simons, 2012) as well as emotional distress (Smith & Rose, 2011). Such negative relational affect cycles, Gross and Medina-DeVilliers point out, are likely to increase each partner's stress level and move the dyadic system away from its balanced set point. Co-rumination is a clear example of a co*dysregulating* relational dimension. The negative relational outcome of co-rumination is quite clear, and as it stands in stark contrast to the beneficial outcomes of coregulation, it helps pinpoint the importance of working towards further identification of ways to establish coregulation in relationships.

The prevailing question, different definitions withstanding, has been whether physiological linkage is a relationally positive, or a relationally negative, occurrence. Timmons, et al. (2015) provide a helpful literature review in answer to that question. They note that, in fact, physiological linkage can relate to both positive relational factors (emotional connectedness or empathy) and negative relational factors (negative affect contagion and conflict escalation). Timmons et al. (2015) suggest instead: “A better question to ask than *whether* linkage is ‘good’ or ‘bad’ may be *when* is linkage ‘good’ or ‘bad’” (p. 720).

Theoretical Rationale for Studying Coregulation

Coregulation, the relationally positive term proposed by Butler and Randall (2013), is a valuable topic of study for present day research as it explores the way both partners in a relationship may mutually benefit from an emotionally regulating interaction. The outcome research on emotional-regulation—which normally focuses on self-regulation—is quite robust. Individual capacity for emotional regulation is a strong predictor of overall mental, social and physical well-being (Eisenberg et al., 2000; John & Gross, 2004). While the positive outcome evidence for self-regulation is quite well-known, there is also evidence that maintenance of top-down self-regulation of affect is a more demanding process than coregulation (Beckes & Coan, 2011). It may be that coregulation, the bidirectional linkage of oscillating emotional channels (Butler & Randall, 2013), is an equally effective means and potentially more efficient way to establish physiological and emotional homeostatic balance. Social baseline theory holds this notion as one of its central assertions: the co-regulatory capacity of human relationships makes them energy efficient in comparison to individual efforts of affect and physiological regulation (Coan et al., 2017).

Social Baseline Theory

Social baseline theory starts at the premise of an economy of action (Beckes & Coan, 2011; Proffitt, 2006). For any organism to live and effectively reproduce, that organism must take in more energy than it expends. Beckes and Coan (2011) assert that, for humans, the most energy efficient state is to be embedded within a social context. The baseline level of human functioning is to be in relationship with others.

Taking an evolutionary perspective, they discuss the immense cognitive resources that a single prehistoric person would have used if they wanted to keep watch over their camp. Compared to this prehistoric loner, a group of five or 10 individuals, collected into a corporate body, share the cognitive and emotional burden of maintaining a vigilant state. Essentially, there are more people available to keep watch, which diminishes the cognitive and metabolic load on everyone within the group, a process sometimes termed "load-sharing." Beckes and Coan argue that modern day humans continue rely on this same social baseline as our body's expected level of functioning for the sale of affective and physiological regulation.

When we are pulled away from that baseline, and we are isolated from mutually coregulating relationships, we demonstrate increases in allostatic load on numerous markers of physiological stress (Gross & Medina-DeVilliers 2020). The process of thermoregulation, for example, is more efficient when feelings of social inclusion are present. In a study that utilized an online ball tossing game, when participants were socially excluded from the game, they exhibited a drop in peripheral body temperature (as measured by finger temperature) that dipped below baseline temperature. Upon social re-inclusion, however, participant finger temperature returned to its usual baseline (IJzerman et al., 2012). Gross and Medina-DeVilliers (2020) suggest that the experience of social exclusion signals to the individual the need to conserve energy, leading to vasoconstriction and the lowering of finger temperature. The inverse then occurs with social inclusion, the individual senses that they need not conserve as many resources, leading to vasodilation and a subsequent increase in finger temperature.

Further, a correlational study found that pregnant women who reported higher social isolation also reported drinking a higher number of sugary beverages. The study also found an inverse correlation between relationship satisfaction and consumption of sugary beverages. These associations remained significant after controlling for psychological and physiological factors like weight related self-image, depression, age, and body mass index (Henriksen et al., 2014). Presumably, individuals who have fallen beneath the necessary baseline of social inclusion, "would need to stockpile resources to compensate for expected costs of acting" (Gross & Medina-DeVilliers, 2020, p. 3). When a person is taken out of the social baseline, they must pursue individual means by which to regulate energy levels, whether this be through the intake of more energy (glucose) or the conservation of energy expenditure (lowering peripheral body temperature).

Additional support for social baseline theory, and the coregulatory power of relationships, is demonstrated when research participants in an fMRI machine expect to receive a mild electric shock. Participants who hold the hand of a close other in anticipation of an electric shock demonstrate diminished activity in the dorsolateral pre-frontal cortex (DLPFC), a region of the brain typically associated with emotional regulation (Coan et al., 2006). These findings were also replicated more recently. This time, in addition to reduced activity in the DLPFC, participants who held the hand of a partner also demonstrated diminished activity in the dorsal anterior cingulate cortex (Coan et al., 2017). Both studies indicate that social support reduces the individual effort that participants must expend on emotional regulation when anticipating threat. A third study found that, compared to participants who were alone, participants who held hands with a partner had diminished activity in a pain-related neural circuit, as well as reduced self-reported pain intensity and unpleasantness (López-Solà et al., 2019).

Finally, the work of Stephen Porges (2001, 2017) also aligns with social baseline theory, and similarly asserts that human biological systems are naturally oriented towards seeking coregulation. Particularly, Polyvagal Theory has brought into greater focus the beneficial health outcomes when people can decrease the activity of their threat-oriented sympathetic nervous system and can instead increase social coregulation.

Notable as the studies of attenuated thermal, glycol and neural activity in the presence of social connection, and increased threat perception and emotional distress in relation to dysregulating relational patterns, Gross and Medina-DeVilliers (2020) point out that these studies are still a measure of how one individual is responding to their environment. They are not studies of coregulation, rather they are studies hinting at the likely plausibility of coregulation. Gross and Medina-DeVilliers encourage that future research seeks to measure the “joint dyadic responses between two conspecifics” (p. 8). In this manner, further research could measure the degree to which relational dyads may reflect a maintenance of, or return to, homeostatic balance.

Early Childhood Research

Further support for the presence of coregulation lies within the study of early parent-child relationships. The seminal work of John Bowlby (1958, 1983), and Mary Ainsworth (1991), clearly established the link between child and caregiver. 60 years of studying human attachment identifies the reality that humans are fundamentally relational. The simple truth is that human development is predicated upon relational connection (Fiskum, 2019).

Meanwhile, Beatrice Beebe and her colleagues have connected the early childhood attachment research to a systems approach that seeks to understand the predictability of facial expressions between parent and child on a moment-to-moment basis. To discuss the predictability of facial behavior they use the terms self-contingency and interactive contingency.

(Beebe et al., 2016; Beebe & Lachmann, 2020, 1998). Self-contingency is similar in concept to the research on autocorrelation (McArdle & Bell, 2000), and it examines an individual's behavior in relation to his or her own prior behavior. Conversely, interactive contingency examines an individual's behavior in relation to their partner's prior behavior (Beebe et al., 2016). From this research Beebe and her colleagues have concluded that self and interactive contingencies are not separate but are instead co-occurring. This means that a relational partner's facial behavior is predicted based on an interaction between his or her prior behavior, as well as the prior behavior of their partner.

To maintain stability within the relational dyad, Beebe and Lachman (2020) say that relational partners must "teeter-totter" between self-contingency and interactive contingency. As both partners in the relationship endeavor to maintain this balance between self-tilt and interactive tilt, they engage in a relational dance of mutual coordination. Relational homeostasis, and the coregulation of affective and physiological functioning, becomes possible when the relational dance has a negative feedback loop (Fogel, 1992; Guastello et al., 2006). An increase in self-tilt from partner A leads to an increase in interactive-tilt from Partner B, which is in-turn met by an increase in interactive-tilt by Partner A. As Partner A begins to move back into relational coordination, Partner B may now respond with a diminished interactive-tilt and an increase in their own self-tilt. This is the dynamic and bidirectional linkage, which leads to affective and physiological stability, that Butler and Randall (2013) defined as coregulation.

Studying Coregulation

As the study of coregulation gains further specificity, Timmons et al. (2015) note that further research needs to continue to parse out potential confounding variables that influence physiological linkage. For example, one study found that an increase in physiological linkage (observed via EDA) predicted an increase in empathy (Chatel-Goldman et al., 2014; Guastello et al., 2006). In a similar manner Gross and Medina-DeVilliers (2020) also suggest that individual differences in attachment relations influence an individual's likelihood of moving towards others for social support. People with positive past relationship experiences are more likely to pursue social engagement to establish physiological-emotional regulation; meanwhile the inverse is true for people with predominately negative relationship experiences.

Another potential confounding variable to physiological linkage is relationship strength. Timmons et al. (2015) suggest that future research should compare linkage between dyads comprised of strangers and dyads comprised of romantic partners. Levenson and Gottman (1983) note that in their research that they specifically chose to study couples because they expected a higher likelihood of observing physiological linkage in closer relationships. Meanwhile, more recent research has observed physiological linkage between strangers during a one-time conversation (Guastello et al., 2006; Kraus & Mendes, 2014) and a problem solving task (Thorson & West, 2018). From their study on physiological linkage during a dyadic math problem-solving task between two strangers, Thorson and West conclude, "the stability of physiology can be affected by anyone we meet in our daily lives, and is, therefore, more susceptible to social influence than previously realized" (2018, p. 93). Continued investigation on the nature of relationship strength is needed to further elucidate its role in both physiological linkage and coregulation.

The presence of physiological linkage is well documented within relationships. Further, the likelihood of coregulation is strongly supported by social baseline research, attachment research and facial expression coding research. Despite the robust research for physiological linkage and the likelihood of coregulatory processes, there have yet to be robust intervention studies on coregulation (Butler, 2017). An intervention study that seeks to increase the degree of coregulation within novel relational dyads could shed helpful light on the topic. It could begin to inform researchers on the elements of a relationship that are central to maintaining homeostatic balance, while also providing direction for potential clinical interventions.

Furthermore, the massive increase in the use of video call technologies in response to the pandemic requires that researchers endeavor to study coregulation while relational partners interface remotely. This holds tremendous importance as a research topic as we increasingly spend our lives interacting with our loved ones, health care professionals, peers, students, and educators through video calls. The need for research exploring the potential for coregulation via remote interaction has become increasingly salient as social interaction throughout the world has been affected by the Covid-19 pandemic. We must continue to study how we can optimally respond as a society to our rapid need and utilization of telecommunication. To answer these questions, this author conducted an intervention study that sought to measure coregulation between new relational dyads formed over video call.

Play and Mutual Coordination: A Proposed Intervention

Porges (2017) describes play as mobilization without fear, meaning that when two relational partners engage in play, their sympathetic nervous systems portray autonomic arousal, and yet that arousal occurs in the absence of fear. By staying connected to the social engagement system, the fight/flight tendencies of sympathetic activation do not hijack the nervous system. Play, then, is a safe experience of being autonomically aroused. Porges (2017) also describes play as a "'neural exercise' that enhances the co-regulation of physiological state" (p. 22). Meanwhile, Tronick (1998) and later Ham and Tronick (2009), in their discussion of dyadic states of consciousness, discuss how individuals enter into shared relational spaces in order to increase the capacity for "mutual regulation" within the dyad. Their research identifies the central role of interactive play for helping maintain this connection between mother and child. For these reasons, a succession of cooperative games was selected as the intervention portion of the study.

Hypotheses

The hypotheses for this study included the following:

H1: This author expected to observe physiological linkage in all dyads, regardless of grouping variable, for both electrodermal activity and heart-rate variability.

H2: This author expected dyads in the intervention group to demonstrate increased mean heart-rate variability at posttest, as well as an attenuated stress response during the stressor portion of posttest, in comparison to the control dyads. Further exploratory analyses included scores from the Adult Attachment Scale (AAS) and the Difficulties in Emotional Regulation Scales (DERS).

Methods

Participants

Participants initially consisted of 42 psychology students, aged 19 to 41 years, from a private university. One participant dropped out before the study began and a second participant dropped out during the pretest. Forty participants completed the entire study. Participants included male (n = 9), female (n = 30) and non-binary (n = 1) students with a wide age range and from a variety of ethnic backgrounds. There were no exclusion criteria for the study. Participation was voluntary and participants volunteered from two undergraduate psychology courses and one graduate psychology course as an opportunity to earn extra credit for their respective course. Informed consent was obtained from each participant prior to conducting the intervention (Appendix A). This study was approved by the Human Subjects Review Committee at George Fox University.

Materials

Physiology

Physiology of both individuals of the relational dyad was measured using the wireless BIOPAC MP160 data acquisition and analysis system (Part #: MP160WSW-FR; see Appendix B for product sheet). Each participant had their own wrist monitor set to different channels so that dyadic physiology could be measured concurrently. The wireless photoplethysmogram (PPG) was used to measure blood volume pulse. PPG data were then converted into the root mean square of successive differences (RMSSD) between heart beats for subsequent statistical analysis. RMSSD is a stable and commonly used measure for calculating HRV. PPG has become an increasingly used method to assess for HRV given its convenient and minimally intrusive nature (Pinheiro et al., 2016). Lower HRV (as measured by RMSSD) is indicative of vagal withdrawal, meaning a withdrawal of the parasympathetic nervous system and subsequent increased activity of the sympathetic nervous system. This results in a more rigid pattern of cardiac responding and is associated with being under stress. Meanwhile higher HRV is indicative of increased vagal tone, meaning increased activity of the parasympathetic nervous system, a more flexible and dynamic pattern of cardiac responding and therefore increased emotional regulation capacity (Porges et al., 1994; Stein et al., 1994).

Electrodermal activity (EDA) was also concurrently measured with PPG. EDA provides a measure (in microsiemens) of skin conductance, or skin sweating activity (Scrimali et al., 2015). Electrodermal response is detected through a measure of microseimens via two electrodes placed on the participant's right palm. Higher EDA has been associated with increased sympathetic nervous system arousal and numerous affective states (Kreibig, 2010).

Data Cleaning

A high frequency pass (0.5 hertz) was run on the PPG data in order to take out any potential data acquisition noise. A smoothing factor of 35 was also run on all PPG files. PPG data were then analyzed to identify QRS peak and cleaned to remove duplicate peaks and replace missing peaks. Phasic EDA was acquired post data acquisition using the AcqKnowledge command "derive phasic EDA from tonic."

Interpolation

A small amount of data was affected by hand-movement artifacts and did not yield a realistic output, even after cleaning procedures. After calculating PPG data to RMSSD, *z* scores were calculated for all RMSSD time phases. Linear interpolation was used to replace all RMSSD date that was above a cut off 2.5 standard deviations above the mean. 13 (out of a total of 320) RMSSD time phases were replaced in this manner. A similar process was completed for EDA data, again using a replacement cut off of 2.5 standard deviations above the mean. 10 (of a total 320) EDA time phases were replaced in this manner.

Emotional Regulation

The Difficulties in Emotion Regulation Scale (DERS) has been widely used as a measure of emotional dysregulation (Gratz & Roemer, 2004). In recent years, an 18-item version of the DERS has been validated, demonstrating strong reliability and validity while reducing strain on participants (Victor & Klonsky, 2016). The DERS-18 was used as a potential confound to measure if self-reported difficulties with emotional regulation relate to difficulties with coregulation as measured by physiological data (see Appendix C for list of items). Self-report on the items ranges from 1-5, 1 meaning “Almost Never” and 5 as “Almost Always” with corresponding percentage values. The DERS-18 items are organized into subscales to attend to constructs such as “Awareness,” “Clarity,” “Goals,” “Impulse,” “Nonacceptance,” and “Strategies.” The DERS-18 has internal consistency within subscale alphas ranging from .77 to .90, for Awareness and both Goals and Impulse, respectively. Overall alpha score for the DERS-18 is .91. (Victor & Klonsky, 2016)

Attachment Style

The Adult Attachment Scale (AAS) was used to assess participants’ attachment style during the pre-test portion of the study (Collins & Read, 1990). This measure is comprised of three main subscales, each comprised of six items: Close, Depend, and Anxiety. These items categorize individuals into Secure, Preoccupied, Dismissive, and Fearful attachment styles. The authors measured internal consistency using three different samples of undergraduate students. (Collins & Read, 1990). The AAS has also been found to have concurrent validity with other comparable attachment scales. Attachment style functioning will be measured as a potential variable which effects coregulatory function within a relational dyad (see Appendix D for list of items).

Relational Proximity

Subjective rating of how well dyad members knew each other was assessed using a 5-point Likert scale (1 = not at all to 5 = extremely well). Participants were asked to rate how well they knew their fellow dyad partner at pretest and again at posttest.

Procedure

The study utilized a pre-post design, with an intermediary intervention period of 3 weeks, for a total of 5 weeks. After volunteering for the study participants were contacted via email and randomly assigned into dyads based on schedule availability. Relational dyads were then randomly assigned into either the control or intervention groups using a random number generator. Two participants dropped out towards the beginning of the study, which required a slight rearrangement of dyad pairings, ultimately resulting in nine dyads the control group and 11 dyads in the intervention group.

All dyads experienced the same procedure at pretest, regardless of grouping variable. Dyad members arrived at the biofeedback lab at the pre-agreed time. They were then taken to separate rooms by either this writer or a research assistant. The Biopac wrist monitor, and electrodes were placed on the participant's non-dominant hand, after which participants completed a packet of questions, including informed consent, DERS, AAS, and subjective rating of how well they knew their fellow participant. Upon completing the question packet the data acquisition systems were started. Participants were encouraged to not move their monitoring hand as much as possible for the duration of the study. Physiological data outputs were monitored for any erroneous responding. Upon completing troubleshooting and systematic checks for reliable physiological responding the research paradigm started. The pretest and posttest both had four distinct time phases (baseline, one-minute greeting, math, and recovery.

Baseline

A physiological baseline was established for three minutes. Preceding this period participants were provided with the same verbatim response to "sit quietly and let their minds relax while a physiological baseline is established."

One-Minute Greeting

After the baseline, a Zoom call was started so the two participants could interface while in different physical rooms. Laptops were placed approximately 16 inches from participants and adjusted for camera height, so participants' faces were clearly in view. The camera view was placed in "gallery" mode, meaning participants had a side-by-side view of themselves and their research partner. After the Zoom call was started participants were given the following instructions, "go ahead and take one minute to introduce yourselves to each other or say 'hi'."

Math

After one minute had elapsed, participants were then introduced to the next portion of the study. A piece of paper with several math problems was placed faced down in front of each participant (math problems borrowed from Thorson and West (2018), see Appendix E). They were then given the following verbatim instructions, "next, you will be asked to complete as many math problems as you can in 3 minutes. You may flip over the paper in front of you now and begin." Upon completion of 3 minutes, participants were thanked for their hard work.

Recovery

Participants were then given the following verbatim instruction, "go ahead and take a breather, feel free to talk to each other as you relax after those difficult math problems." Participants were then allowed to talk freely for the duration of 3 minutes. After the end of 3 minutes, participants were notified that the study was done. They were thanked for their time and a follow up time was agreed upon for subsequent sessions.

The same procedure was utilized at pretest and posttest, the only difference being that at posttest participants did not re-answer the packet of questions with the AAS and DERS. During the pretest and posttest researchers took care to sit as far away from participants as possible in order to maintain minimal interaction and potential confounding effects on physiological responses due to researcher interaction.

The 3 intervening weeks between pretest and posttest comprised the intervention portion of the study. For these 3 weeks, the intervention dyads met with each other and this author for a weekly Zoom call. Each week participants played a different cooperative/goal-sharing game with their dyad partner. These games required dyad members to work together to complete a shared goal in a non-competitive framework (see Appendix F). These Zoom calls lasted 20 minutes each week. Meanwhile the control dyads also met with this author weekly on a Zoom call for 20-minute periods. They differed, however, in that the control dyads were shown a 20-minute travel video. This meant control dyad members were instead privy to a shared neutral stimulus without relational interaction, collaboration, or goal-sharing.

Results

The first hypothesis proposed in this study predicted the presence of physiological synchrony within relational dyads at both pretest and posttest, independent of the grouping variable as measured by the correlations of the participant's' heart variability (as measured by RMSSD) and electrodermal activity (EDA). The second hypothesis predicted the intervention dyads would exhibit greater mean coregulation across the dyad at the posttest than the control dyads, indicated by higher RMSSD across all four time phases, along with a return to physiological baseline after a stressor (math problems). Table 1 shows the overall demographics of all participants, with a final total sample size of $n = 40$, 20 relational dyads. Two participants (not in the same dyad) dropped out at the pretest which necessitated a reorganization of some of the dyads, resulting in nine dyads in the control condition and 11 dyads in the experimental condition.

Table 1

Demographics

Factor	Total sample		Intervention group		Control group	
	n	%	*n*	%	*n*	%
Gender						
Male	9	22.5	6	27.3	3	16.7
Female	30	75.0	16	72.7	14	77.8
Non-binary	1	2.5	0	0.0	1	5.6
Race						
European American	27	67.5	16	72.7	11	61.1
Asian American	5	12.5	1	4.5	4	22.2
Latinx American	5	12.5	3	13.6	2	11.1
Biracial/Multiracial	3	7.5	2	9.1	1	5.6
Age						
19 years	4	10.0	2	9.1	2	11.1
20 years	11	27.5	7	31.8	4	22.2
21 years	6	15.0	2	9.1	4	22.2
22 years	7	17.5	2	9.1	4	22.2
24 years	1	2.5	0	0.0	1	5.6
25 years	4	10.0	3	13.6	1	5.6
26 years	1	2.5	0	0.0	1	5.6

Factor	Total sample		Intervention group		Control group	
	n	%	*n*	%	*n*	%
27 years	1	2.5	1	4.5	0	0.0
28 years	1	2.5	1	4.5	0	0.0
29 years	1	2.5	1	4.5	0	0.0
30 years	1	2.5	1	4.5	0	0.0
41 years	1	2.5	1	4.5	0	0.0
Missing	1	2.5	1	4.5	0	0.0

Note. $N = 40$ ($n = 22$ for intervention group, $n = 18$ for control group).

Hypothesis 1 Findings

Bivariate correlations were used to assess potential correlations between the physiological responses of participant 1 and participant 2 across the four, time phases (baseline, 1 minute greeting, math, and recovery), at both pre and posttest. The Split File function in SPSS was utilized to separate bivariate analysis by grouping variable. Tables 2 and 3 display RMSSD data for pre-test and post-test, respectively. Tables 4 and 5 display EDA data for pre-test and post-test, respectively. The bottom left of the tables show data for the control group whereas the top right of the tables show data for the intervention group.

RMSSD Findings

The control dyads at pre-test demonstrated just three significant correlations. One correlation was an autocorrelation $r = .832$, $p < .01$, a predictive relationship between a single participant's initial and subsequent physiological activity, between the participant 2 at Baseline and participant 2 at Greeting. Two of the correlations were synchrony-based, which indicates the two participants were responding similarly to each other, such that one participant's physiological activity is predictive of the other participant. There was a correlation between participant 1 and participant 2 at Baseline $r = .719$, $p < .05$ and again during at Math $r = .739$, $p < .05$.

The intervention dyads demonstrated more correlations overall at pre-test, the majority of which were autocorrelations. There were eight autocorrelations in total, four of which were across time phases for participant 1 and four of which were across time phases for participant 2 (see Table 2). Two of the correlations were synchrony-based. There was an unexpected negative correlation between participant 2 at Greeting time phase and participant 1 at Math time phase $r = -.624$, $p < .05$. There was a second negative correlation between participant 1 and participant 2 during Math $r = -.626$, $p < .05$.

Table 2

Synchrony or Autocorrelation: RMMSD Pre-Test

Variable	Base1	Base2	Greet1	Greet2	Math1	Math2	Recov1	Recov2
Base1	—	−.51	.44	−.35	**.80****	−.51	.43	−.52
Base2	*.72**	—	−.26	**.61***	−.54	**.78****	−.30	**.62***
Greet1	.46	.17	—	−.20	**.70***	−.27	**.85****	−.03
Greet2	.63	**.83****	−.19	—	*−.62**	.53	−.30	**.76****
Math1	.39	−.22	.49	−.22	—	*−.63**	**.71***	−.47
Math2	−.06	−.40	.48	−.59	*.74**	—	−.36	**.61***

Variable	Base1	Base2	Greet1	Greet2	Math1	Math2	Recov1	Recov2
Recov1	.18	−.26	.62	−.56	.55	.53	—	−.17
Recov2	−.31	−.40	.23	−.19	.15	.51	−.06	—

Note. RMMSD = Root mean square of successive differences; Base1 = Participant one at baseline time phase; Base2 = Participant two at baseline time phase; Greet1 = Participant one at greeting time phase; Greet2 = Participant two at greeting time phase; Math1 = Participant one at math time phase; Math2 = Participant two at math time phase; Recov1 = Participant one at recovery time phase; Recov2 = Participant 2 at recovery time phase.

$^{*}p < .05$, two-tailed. $^{**}p < .01$, two-tailed. **Bold** = autocorrelation. *Italics* = synchrony correlation

The control dyads demonstrated two autocorrelations at post-test. Participant 1 at Baseline correlated with participant 1 at Recover $r = .820$, $p < .01$ and participant 2 at Greeting correlated with participant 2 at Math $r = .803$, $p < .01$. The control dyads did not demonstrate any synchrony-based correlations at post-test.

The intervention dyads demonstrated five autocorrelations (see Table 3) and two synchrony-based correlation at post-test. One synchrony-based correlation occurred between participant 2 at Greeting and participant 1 at Recovery $r = .642$, $p < .05$. A second synchrony-based correlation occurred between participant 2 at Baseline and participant 1 at Math $r = .66$, $p < .05$. Across pretest and posttest, the RMSSD data demonstrated greater evidence of autocorrelation than synchrony-based correlation.

Table 3

Synchrony or Autocorrelation: RMMSD Post-Test

Variable	Base1	Base2	Greet1	Greet2	Math1	Math2	Recov1	Recov2
Base1	—	.43	.35	.23	**.73***	.41	.40	.12
Base2	.26	—	.13	**.67***	*.66**	.43	.18	**.74****
Greet1	.51	.52	—	.44	.36	.47	**.69***	.15
Greet2	−.52	.05	−.16	—	.47	.27	*.64**	**.68***
Math1	.56	.44	.20	−.53	—	.25	.38	.27
Math2	−.60	−.07	−.08	**.80****	−.52	—	.07	.47
Recov1	**.82****	.03	.41	−.61	.50	−.37	—	.22
Recov2	.27	.22	.19	.53	−.04	.24	.07	—

Note. RMMSD = Root mean square of successive differences; Base1 = Base1 = Participant one at baseline time phase; Base2 = Participant two at baseline time phase; Greet1 = Participant one at greeting time phase; Greet2 = Participant two at greeting time phase; Math1 = Participant one at math time phase; Math2 = Participant two at math time phase; Recov1 = Participant one at recovery time phase; Recov2 = Participant 2 at recovery time phase.

$^{*}p < .05$, two-tailed. $^{**}p < .01$, two-tailed. **Bold** = autocorrelation. *Italics* = synchrony correlation

EDA Findings

Across intervention and control dyads, at both pretest and posttest, EDA data demonstrated widespread and consistent evidence of robust autocorrelations and no evidence of synchrony-based correlations. At the pre-test, both intervention and control dyads demonstrated the maximum number of autocorrelations (all participant 1 time phases correlated with all other participant 1 time phases; all participant 2 time phases correlated with all other participant 2 time phases). Moreover, all but two of these autocorrelations were significant at $p < .01$ (see Table 4).

Table 4

Synchrony or Autocorrelation: EDA Pre-Test

Variable	Base1	Base2	Greet1	Greet2	Math1	Math2	Recov1	Recov2
Base1	—	−.18	**.86****	−.14	**.85****	−.02	**.69***	−.08
Base2	.09	—	−.45	**.99****	−.34	**.96****	−.31	**.94****
Greet1	**.91****	.03	—	−.46	**.92****	−.36	**.71***	−.37
Greet2	.08	**.98****	.03	—	−.31	**.97****	−.28	**.95****
Math1	**.98****	.5	**.94****	.13	—	−.19	**.87****	−.18
Math2	.05	**.98****	−.00	**.99****	.10	—	−.16	**.98****
Recov1	**.94****	.12	**.95****	.09	**.97****	.07	—	−.11
Recov2	.06	**.96****	.03	**.99****	.12	**.99****	.09	—

Note. EDA = Electrodermal activity; Base1 = Base1 = Participant one at baseline time phase; Base2 = Participant two at baseline time phase; Greet1 = Participant one at greeting time phase; Greet2 = Participant two at greeting time phase; Math1 = Participant one at math time phase; Math2 = Participant two at math time phase; Recov1 = Participant one at recovery time phase; Recov2 = Participant 2 at recovery time phase.

$^{*}p < .05$, two-tailed. $^{**}p < .01$, two-tailed. **Bold** = autocorrelation. *Italics* = synchrony correlation

At the post-test, the control dyad participant 2's again demonstrated the maximum number of autocorrelations, five at $p < .01$ and one at $p < .05$. Meanwhile, the control dyad participant 1's demonstrated autocorrelations between all time phases except Baseline-Recovery and Greeting-Recovery. Two of the control dyad participant 1 autocorrelations were at $p < .05$ and 2 were at $p < .01$. At the post-test, the intervention dyads again demonstrated the maximum number of autocorrelations, all but one at $p < .01$ (see Table 5).

Table 5

Synchrony or Autocorrelation: EDA Post-Test

Variable	Base1	Base2	Greet1	Greet2	Math1	Math2	Recov1	Recov2
Base1	—	.31	**.98****	.23	**.97****	.15	**.97****	.00
Base2	−.60	—	.32	**.96****	.23	**.95****	.23	**.90****
Greet1	**.79***	−.43	—	.23	**.99****	.14	**.99****	−.01
Greet2	−.46	**.79***	−.27	—	.14	**.98****	.13	**.96****
Math1	**.77***	−.44	**.83****	−.16	—	.05	**.99****	−.09
Math2	−.58	**.92****	−.31	**.88****	−.22	—	.05	**.98****
Recov1	.39	−.28	.61	−.05	**.87****	−.00	—	−.10
Recov2	−.57	**.85****	−.38	**.88****	−.26	**.97****	−.07	—

Note. EDA = Electrodermal activity; Base1 = Base1 = Participant one at baseline time phase; Base2 = Participant two at baseline time phase; Greet1 = Participant one at greeting time phase; Greet2 = Participant two at greeting time phase; Math1 = Participant one at math time phase; Math2 = Participant two at math time phase; Recov1 = Participant one at recovery time phase; Recov2 = Participant 2 at recovery time phase.

$^{*}p < .05$, two-tailed. $^{**}p < .01$, two-tailed. **Bold** = autocorrelation. *Italics* = synchrony correlation

The data only partially supports hypothesis 1, dyads demonstrated only minimal evidence of physiological synchrony and instead exhibited more robust findings of physiological autocorrelation. RMSSD data exhibited minimal evidence of synchrony correlations between participants (six in total, two of which were inverse correlations) and instead supported moderate findings of autocorrelations within participants (17 in total). The intervention dyads demonstrated more autocorrelations than the control dyads at both pretest and posttest. Meanwhile the EDA data demonstrated clear and robust evidence of physiological autocorrelation at pretest and posttest and across the grouping variable. EDA data provided no evidence of physiological synchrony. Implications will be discussed below.

Hypothesis 2 Findings

The mean RMSSD between participant 1 and participant 2 was calculated across all time phases for all dyads. Paired samples t-test matrices were calculated to investigate potential significant increases or decreases in mean dyad RMSSD for all four time phases of the pretest and then again at posttest (a mean increase signaling an increase in vagal tone and a mean decrease signaling vagal withdrawal). Paired samples t-test matrices were also calculated to investigate potential differences in mean RMSSD between pretest and posttest. The spilt-file function in SPSS was utilized to separate paired samples t-tests by grouping variable. Finally, independent samples t-tests were used to investigate potential significant differences in mean RMSSD between intervention and control groups.

Differences Between Time Phases

At pre-test the control dyads demonstrated a significant decrease in RMSSD from Greeting to Math $t = 1.911$, $p < .05$, with a moderate effect size Cohen's $d = .637$. Further, control dyads then exhibited a significant increase in RMSSD from Math to Recovery $t = -4.457$, *p* < .01, with a large effect size Cohen's *d* = -1.486. There was not a significant difference between Baseline and Recovery *p* > .05, which indicates that control dyads returned to their physiological baseline during the recovery period (see Table 6).

Table 6

Coregulation: Paired Sample T-tests at Pre-Test

	Control		Intervention	
	t	*d*	*t*	*d*
Baseline - Greeting	−1.37	−0.46	0.81	−0.03
Greeting - Math	1.91*	0.64	1.72	0.52
Math - Recovery	−4.46**	−1.49	−2.66*	−0.80
Baseline - Recovery	−1.36	−0.45	−0.70	−0.21

*$p < .05$, one-tailed. **$p < .01$, one-tailed.

At pre-test the intervention dyads did not demonstrate a significant difference from Greeting to Math. However, they did exhibit a significant increase in RMSSD from Math to Recovery *t* = -2.658, *p* < .05, with a moderate effect size Cohen's *d* = .801. Like the control dyads, there was not a significant difference between Baseline and Recovery *p* > .05, which indicates the intervention dyads also returned to their RMSSD baseline during the recovery period (see Table 6).

At post-test control dyads demonstrated a significant decrease in RMSSD from Greeting to Math *t* = 2.300, *p* < .05, with a moderate effect size Cohen's *d* = .767. They also exhibited a significant increase in RMSSD from Math to Recovery *t* = -3.603, *p* < .01, with a large effect size Cohen's *d* = -1.201. Control dyads also demonstrated a significant increase in RMSSD from Baseline to Recovery *t* = -2.257, *p* < .05, with a moderate effect size Cohen's *d* = -.752. The significant increase suggests control dyads at posttest surpassed their physiological baseline during the recovery period (see Table 7).

Table 7

Coregulation: Paired Sample T-tests at Post-Test

	Control		Intervention	
	t	*d*	*t*	*d*
Baseline - Greeting	0.21	0.07	1.84^{*}	0.56
Greeting - Math	2.30^{*}	0.77	1.22	0.37
Math - Recovery	-3.60^{**}	−1.20	-3.14^{**}	−0.95
Baseline - Recovery	-2.26^{*}	−0.75	0.26	0.08

$^{*}p < .05$, one-tailed. $^{**}p < .01$, one-tailed.

At post-test intervention dyads demonstrated a significant decrease in RMSSD from Baseline to Greeting $t = 1.839$, $p < .05$, with a moderate effect size Cohen's $d = 0.555$. There was a non-significant decrease in RMSSD from Greeting to Math $p > .05$. They exhibited a significant increase in RMSSD from Math to Recovery $t = -3.144$, $p < .01$, with a large effect size Cohen's $d = -0948$. Finally, there was not a significant difference between Baseline and Recovery $p > .05$. This indicates the intervention dyads returned to their physiological baseline during the recovery period during the posttest (see Table 7).

Differences Between Pretest and Posttest

Paired sample t-tests were used to assess for potential difference in mean dyad RMSSD between pretest and posttest. No differences were detected between pretest time phases and posttest time phases, regardless of the grouping variable $p > .05$. Moreover, effect sizes for the intervention between pretest and posttest were small, whereas the control group had to moderate effect sizes between pretest-posttest phases of Greeting and Math (see Table 8).

Table 8

Differences Between Pre-Test and Post-Test

	Control		Intervention	
	t	*d*	*t*	*d*
Baseline	0.49	0.16	−1.24	−0.37
Greeting	1.68	0.56	0.62	0.19
Math	1.63	0.54	−0.24	−0.07
Recovery	0.68	0.26	−0.50	−0.15

$^{*}p < .05$, one-tailed. $^{**}p < .01$, one-tailed.

Differences Between Groups

Independent samples t-test assessed for potential groups differences at all time phases for both pretest and posttest (Table 9). Levene's tests for equality of variances were all insignificant $p > .05$, so equal variances were assumed for all time phases. There were no significant differences between groups at pretest, $p > .05$ for all time phases. At posttest Baseline the intervention group had a significantly higher RMSSD than the control $t = -1.734$, $p < .05$, with a moderate effect size Cohen's $d = -.780$. There was not a significant difference between groups at posttest Math, $p > .05$, however there was a moderate effect size Cohen's $d = -.643$ (see Table 9).

Table 9

Independent Samples T-test: Between Control and Intervention Groups

	Differences at pre-test		Differences at post-test	
	t	*d*	*t*	*d*
Baseline	−0.18	−0.08	−1.73*	−0.78
Greeting	0.52	0.24	−0.55	−0.25
Math	0.56	0.25	−1.43	−0.64
Recovery	1.11	0.50	−0.21	−0.09

*$p < .05$, one-tailed. **$p < .01$, one-tailed. [a]Levene's test of equality of variances is significant, $p < .05$.

The data are largely in favor of the null for hypothesis two of the study. The intervention dyad did not demonstrate a significant increase in RMSSD between pretest and posttest, nor they did they demonstrate a significant increase in comparison to the control group. The intervention group did exhibit a significant higher resting RMSSD at posttest Baseline compared to the control dyads. However, these significant differences did not hold across the time phases of the posttest. Further the difference in posttest Baseline was due to a significant decrease from the control dyads, and not due to a significant increase from the intervention dyads. There was no difference in mean RMSSD at Posttest Math, nor at Posttest Recovery, suggesting that the controls functioned equally as well as the intervention dyads during the stressor and recovery periods. A moderate effect size between groups at Posttest Math may suggest that a larger sample size would have revealed a significant difference between groups during the stressor portion of the experiment. Such a significant finding would be in favor in the hypothesis and the expectation that the intervention dyad would have exhibited an attenuated stress response during Math because of a coregulating effect.

Results did demonstrate a significant decrease in mean RMSSD across all dyads during the Math (stressor) portion. This affirms that math problems are a sufficient stressor for use in an experimental paradigm and lead to a consistent pattern of vagal withdrawal. Further, results also indicate a significant increase in RMSSD from the Math to Recovery in both pretest and posttest, for both control and intervention group. This suggests a robust effect of social interaction as a means of allowing dyads to effectively return to physiological baseline after a stressor.

Exploratory Analyses

Exploratory analyses of this study included an analysis of attachment style and RMSSD, DERS and RMSSD, and subjective rating of how well dyad members knew each other. Implications will be discussed below.

Attachment and RMSSD

An analysis of variance (ANOVA) assessed potential differences between the three attachment styles of the study population (secure, preoccupied, dismissive) and RMSSD output. All time phases at both pretest and posttest were investigated for potential differences. The ANOVA revealed no significant differences ($p > .05$) between attachment style and RMSSD output. There were no differences regardless of time phase of the experiment, along with no differences regardless of pretest or posttest (Table 10).

Table 10

Attachment Styles

	Total sample	Intervention group	Control group
Secure	57.5% (23)	45.5% (10)	72.2% (13)
Preoccupied	32.5% (13)	40.9% (9)	22.2% (4)
Dismissive	10.0% (4)	13.6% (3)	5.6 % (1)

Note. $N = 40$ ($n = 22$ for intervention group, $n = 18$ for control group).

DERS and RMSSD

Bivariate correlation matrices assessed for potential correlations between the six DERS subtests and all RMSSD time phases at both pretest and posttest. There were three significant correlations. The DERS-clarity subtest correlated with the posttest greeting time phase $r = .332$, $p < .05$. Meanwhile the DERS-strategies subtest correlated with the posttest greeting time phase $r = .392$, $p < .05$ and with posttest recovery time phase $r = .425$, $p < .05$. All other subtests at all other time phases were insignificant $p > .05$.

Connection to Fellow Participant

Each participant was asked to rate how well they knew their fellow participant within the dyad on a 5-point Likert scale (1 = not at all to 5 = extremely well). Participants were asked this question at the beginning of the pretest and again at the beginning of the posttest. Mean ratings were calculated across the dyad.

An independent samples t-test assessed for potential differences between groups at both pretest and posttest. Levene's test for equality of variances was not significant $p > .05$ at both pretest and posttest, so equal variances were assumed. Groups were not different in subjective rating of how well the participants knew each other at pretest $t = 1.12$, $p > .05$ or posttest $t = 1.63$, $p > .05$. There was, however, a moderate effect size at posttest Cohen's $d = 0.73$, suggesting that an increase in power may have revealed that the intervention dyads knew each other to a significantly greater degree than the control dyads.

Paired samples t-tests assessed for differences between pretest and posttest within groups. The control dyads $t = 4.26$, $p < .01$ Cohen's $d = 1.42$ and the intervention dyads $t = 4.04$, $p < .01$ Cohen's $d = 1.22$ both demonstrated significant increases in subjective rating of how well they knew their fellow participant.

Discussion

Summary of Hypotheses and Results

Hypothesis 1: Synchrony v. Autocorrelation

The first hypothesis of this study predicted the presence of physiological synchrony across dyads, this was largely unsupported. There was a robust demonstration of autocorrelation for the EDA data at both pretest and posttest, regardless of grouping variable. The RMSSD data was more mixed, with some synchrony-based correlations across time phases and some autocorrelations across time phases. Beebe and Lachmann (2020) discuss the simultaneous movement between self-tilt and interactive tilt to suggest that coregulation and self-regulation are mutually occurring processes. This mutual occurrence may be a partial reason as to why the RMSSD data showed some evidence of synchrony and some evidence of autocorrelation; it highlights the potential for a nuanced pattern of interpersonal interaction rather than an all-or-nothing regulation paradigm. It could be that the identified pattern for RMSSD data, which involved autocorrelations and synchrony-based correlations, could in fact be indicative of this mutual danced that Beebe and Lachmann identify in their facial micro-expression data. It is notable, however, that the EDA data does not represent this balance of synchrony and autocorrelation, as it was instead and overtly clear demonstration of autocorrelation. This raises questions about the nature of difference physiological measures, and how they may be sensitive to different environmental stimuli. It may be that HRV is more subject to interpersonal interactions than EDA, or it may be that HRV shifts more quickly in smaller time intervals than EDA.

It is important to consider potential reasons why physiological synchrony did not arise as a more robust pattern, particularly as this is one of the first prospective physiological dyadic studies carried out over video call. Geller (2021) provided a helpful overview of potential factors that could affect interpersonal presence over video call. One potential factor is the consideration that during the pretest and posttest, participants had a view of themselves side-by side with a view of their partner on the computer monitor. This writer wonders if the presence of a self-view increases the degree of self-referencing that participants did during the experimental paradigm, potentially disrupting their ability to mutually move towards each other. In the language of Beebe and Lachmann, perhaps the presence of a self-view camera increases self-tilt and self-referencing, and thereby decreases other tilt, or the co-creation of a "dyadically expand state of consciousness" (Tronick, 1998). Anecdotal statements by many therapist colleagues of this writer suggest that they find it helpful to turn off their self-view while conducting therapy in a video call format. This would be a valuable avenue of future study.

Another potential reason for the lack of physiological synchrony could be that, when not in-person, relational partners might not able to pick up on each other's affective, mostly subconscious, signaling. Allan Schore (2011) discusses this extensively, noting that a tremendous amount of interpersonal communication happens on a "right brain to right brain" basis. As we think further about the way our brain gathers information interoceptively from within the body, it may be that the lack of mutual postural information reduces the prominence of physical mirroring, which thereby diminishes the unconscious somatic and affective transference between relational partners (Ogden & Goldstein, 2019). The video call environment narrows the visual field to only what is shown on the screen, vastly limiting this physical reciprocal mirroring.

A final consideration could be that, even on the most stable of video calls, there is a constant delay in the transmission of information. This time delay may disrupt the mutual interactive tilt which is so necessary for physiological synchrony. Without immediate and embodied feedback from a relational partner, perhaps both partners subtly withdraw from the encounter, moving towards a self-tilt orientation.

As video call interactions are not going away, it remains important to consider why physiological synchrony may not have been observed in a robust manner in this study, and how it could potentially be improved.

Hypothesis 2: Coregulation

The second hypothesis predicted that a relational interaction intervention would yield increased coregulation for intervention dyads at the posttest compared to the control dyads. Data predominately supported the null hypotheses, however moderate effect sizes indicated that an increased study population or a more powerful intervention may have resulted in significant differences.

One important finding demonstrated that all dyads returned to physiological baseline during the recovery phase. The experimental paradigm on a whole proved to be robust, as the stressor induced a significant reduction in RMSSD for all dyads. These findings demonstrate that the recovery phase provided ample time for dyads to mutually recover from the stressor phase. Moreover, it suggests that social engagement alone, and without facilitated intervention, has the strong capacity to help a new relational dyad recover from a stressor, even over a video call format. This is a remarkably exciting finding, indicating that people are able to benefit from the coregulating capacity of new relational partners, even over a video call format. Further, because there were no significant differences between control group and intervention group, it is possible that the three-minute social engagement recovery period was itself more powerful than the intervention. Or, in other words, three minutes of social engagement "washed out" out the effects of the intervention.

There were also important findings regarding comparisons between intervention and control groups. The intervention dyads did have significantly higher resting RMSSD at posttest compared to control dyads. It is possible, then, that the intervention helped to attenuate arousal prior to the beginning of the posttest. Further, while not significantly different, there was a moderate effect size in favor of the intervention dyads during the posttest stressor. This means that, with a larger sample size or a more powerful intervention, it is possible there would have been a significantly attenuated stress response from the intervention dyads compared to the controls. Such a finding would be in line with the notion of coregulation, which is that it helps the relational system maintain its position near homeostatic balance by buffering stressors (Butler & Randall, 2013). Essentially, we would expect to see that a coregulating dyad does not experience as much stress from a stressor.

While not in full support of the hypothesis these are exciting findings. From this portion of the study, we gather that relationship partners, while on a video call, suggest the ability to coregulate back to baseline after experiencing a stressor. This has tremendous implications for the power of telehealth and teletherapy interventions. Further research specificity is needed, however, as we continue to elucidate the differences and similarities between the constructs of coregulation and physiological synchrony.

Further, this study suggests that it may be possible for dyads to increase the coregulatory capacity of their relationship while only interacting over video call. Given the observed moderate effect size, a longer intervention with more affectively salient interactions may yield differences between intervention and control dyads in future studies. This provides great hope for the efficacy of video call and telehealth therapies, while also promoting efficacy in the field with the general notion that we can and should seek to improve our modalities, whether they are remote or in person.

Exploratory Analyses

Exploratory analyses included the investigation of whether attachment typing from the Adult Attachment Scale (AAS), and subtests of the Difficulties in Emotional Regulation Scale (DERS-18), related to RMSSD output, along with an investigation of whether the subjective rating of how well participants knew each other was related to RMSSD at posttest. Data revealed no difference in RMSSD based on attachment style. This differs from others who have documented that attachment security related to greater HRV reactivity and higher HRV recovery after a stressor (Steffen et al., 2021). Further, Schreiber et al. (2021) identified that differences in attachment security related to differential patterns in aligning with a partner's physiology (attachment dependence) and misaligning with a partner's physiology (attachment avoidance). It is notable that the lack of finding here may have been due to a preponderance of attachment security amongst the study population. Further studies of attachment, linkage and regulation could continue to seek to validate psychological constructs through objective physiological patterning.

The DERS subtest of Clarity correlated with just one of the eight RMSSD time phases, whereas the subtest Strategies correlated with two RMSSD time phases (posttest greeting and recovery). The Strategies subtest relates to a person's ability to flexibly use situationally appropriate strategies to modulate intensity or duration of emotional experiences (Victor & Klonsky, 2016). It makes sense, then, that this subcategory of the DERS would correlate with RMSSD, particularly during relational interactions.

The final portion of exploratory analyses questioned whether the subjective rating of how well participants knew each changed from pretest to posttest, and whether it differed by grouping variable. First, results revealed that the control and intervention groups were not different at pretest or posttest. This finding is expected at pretest and a testament to the benefit of random sampling. At posttest the difference between groups was not significant, however there was a moderate effect size in favor of the intervention dyad. This again corroborates the findings from the second hypothesis, that a more powerful intervention or larger study size may have yielded significant differences between groups.

Second, both intervention and control dyads demonstrated a significant increase in their subjective report of how well they knew their dyadic partner from pretest to posttest. This is demonstrative of the capacity to become more familiar with others over a video call format. This also demonstrates that the control dyad appeared to benefit from the social engagement during the experimental paradigm to a significant degree, despite not being exposed to the intervention. This further connects to the second hypothesis findings, which suggest that the interaction during the pretest and posttest was itself more powerful than the intervention. In both RMSSD and subjective rating of connection between dyadic partners we see clear evidence that all dyads benefitted from the social engagement, which was embedded in the experimental paradigm, potentially to such a degree that it washed out any effects from the intervention. At the same time, moderate effect sizes for posttest RMSSD and posttest subjective rating of fellow participant lean in favor of the intervention dyads, suggesting that a more powerful intervention could yield significant effects.

Contributions to Research

Prior to this study the author found no publication of an investigation of physiological synchrony and coregulation over a video call format (consistent with a Scopus search as recent as March 2022). This research is tremendously important as massive amounts of social interaction shifted to video call interaction in reaction to the pandemic. Even as social distancing requirements are being lifted at the time of writing this publication, it is likely telehealth services will continue to be a prominent modality of therapy as well as continued use of virtual platforms for communication between co-workers, friends, and families.

Additionally, prior to this study, the author found no evidence of an intervention study that sought to increase coregulatory capacity of relational dyads. As numerous fields continue to corroborate the centrality of relational regulation and its mediating effect on traumatic stress and allostatic load, this remains a very important topic of study.

Implications

This study suggests a robust effect of social engagement towards the restoration of vagal tone after a vagal withdrawal. That this was observed amongst new relational dyads is strongly encouraging for the potential effects of video call interactions. It may be that video call interactions can be a sufficient means to regulating affect across a dyad. This sheds positive light on the continued use of videoconference in numerous areas of society, including healthcare, mental health therapy and education. One on one interactions, even over video call, can prompt a restoration of physiological regulation.

A further finding of this study hints at the possibility that relational dyads may have the capacity to increase in coregulation, particularly in the direction of attenuating withdrawal and maintaining vagal tone during a laboratory stressor. This would be a tremendous finding if further studies could verify this with a longer or more powerful intervention. Stress buffering and withstanding the effects of allostatic load should be central objects of research as we continue to identify the problematic effects of chronic stress and chronic trauma. This also sheds hopeful light on the capacity for relationships in all facets of life to increase the mutual regulation of stress, suggesting we can take strident steps towards cultivating more regulated and resilient communities.

Limitations

Limitations of this study include a statistically small sample size. As dyadic research studies the relationship as the most indivisible unit of research, it effectively doubles the requisite sample size of studies and amplifies the logistical complication of research. Another limitation of this study was that it did not utilize the highly complex dynamic mathematical modeling that has been suggested elsewhere (Thorson et al., 2018) for the purposes of studying moment-by-moment dyadic shifts in physiological contingencies. It may be that increased statistical specificity would have revealed even clearer evidence for the “mutual dance of coregulation” discussed by others (Beebe & Lachmann, 2020; Butler, 2015).

Directions for Future Research

This study hints at the presence of dyadic physiological coregulation to baseline during a recovery phase, and yet given the lack of observed physiological synchrony, a further question must be asked: did this study observe dyadic coregulation, or mutually occurring self-regulation? A different angle from which to approach this question is to ponder whether physiological synchrony is in fact a precursor to physiological and affective coregulation. To this point extant literature has tended to conflate these terms whereas Butler and Randall have demonstrated in numerous publications that coregulation is affectively and physiological distinct from the mere presence of physiological linkage. Moreover, Beebe and Lachmann (2020) and Butler (2015) discuss the mutual dance between self and interactive contingencies that are necessary for the delicate balance of systemic regulation. Self and coregulation are delicate processes that likely happen in tandem. These minute affective and physiological shifts likely demand increased statistical specificity and dynamic modeling (Butler et al., 2017; Guastello et al., 2006), which extended beyond the methodological scope of this study.

Finally, this study prompts a suggestion for future research, which would be a replication of this design with the addition of a third group that does not receive social engagement during the recovery of a stressor. While the data of this study hints at the likely prominence of coregulation, we must further ponder if the robust return to baseline after a stressor was in fact due to coregulation, or whether it was purely a measurement of mutual self-regulation. Further studies should also seek to identify patterns of dyadic physiological processes across myriad forms of electronic communication as we continue to strive to understand the results of our increasingly disembodied forms of communication. Finally, as the burgeoning field of research validates the presence and occurrences of coregulation, more studies are needed to identify the potential for relational dyads to increase their coregulatory capacity. Such research could be instrumental in guiding future interventions in healthcare, education, psychotherapy, child affective development and team performance. Further physiological dyadic studies are important for the growth of our field and science as we continue to strive towards a more regulated and resilient world.

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Appendix A: Informed Consent

Introduction
Thank you for agreeing to participate in this research study. The purpose of this research is to assess interpersonal interactions over a video call.

Your Involvement
You will be asked to attend one research session a week for the next six weeks. During the course of these weeks you will be asked to answer a few questionnaires, solve problems with your research partner, and have your heart rate and skin conductance measured (first and last sessions only). By completing all six sessions you will be rewarded 8 SONA credits for participation in research. The first and last sessions will take approximately 35 minutes of your time, whereas sessions 2-5 will take 15 minutes of your time. You will be contacted through email to schedule future sessions.

Risks and Benefits
There is no physical risk for this study. Mild psychological discomfort may occur during the problem-solving tasks. Benefits include working with others, being a helpful participant in a research study, and receiving class compensation. This study will help mental health professionals better understand how social interaction helps with relaxation.

Confidentiality
You will be asked to print your name on this confidentiality form as a way of keeping track of your SONA/class credits. All of your answers on questionnaires will be kept completely confidential and your stress response data will be kept anonymous.

Future Questions
If you have any questions about this study or the procedures, you may be contact the primary researcher Zak Buckles, M.A. by calling 253-670-4566 or Mary Peterson, Ph.D. at 503-554-2377.

Participation
Your participation in this study is completely voluntary and you may decline to participate without penalty. If you decide to participate, you may withdraw at any time without penalty, at which point you will receive SONA/class credits equal to the number of sessions you have attended so far. If you withdraw from the study before data collection is completed your data will be deleted. Your signature of this consent form, and participation in future sessions, constitutes your consent to participate.

______________________________ ______________________________

Sign Name Here *Print Name Here*

Appendix B: BIOPAC Product Sheet

See: https://www.biopac.com/wp-content/uploads/MP160-Systems.pdf

Appendix C: DERS Questionnaire (Viktor & Klonsky, 2016)

Items of the DERS-18 Questions are answered on a Likert scale from 1 (almost never applies to me) to 5 (almost always applies to me).

(r) means reverse score.

1. I pay attention to how I feel. (r)
2. I have no idea how I am feeling.
3. I have difficulty making sense out of my feelings.
4. I am attentive to my feelings. (r)
5. I am confused about how I feel.
6. When I am upset, I acknowledge my emotions. (r)
7. When I am upset, I become embarrassed for feeling that way.
8. When I am upset, I have difficulty getting work done.
9. When I am upset, I become out of control.
10. When I am upset, I believe that I will remain that way for a long time.
11. When I am upset, I believe that I will end up feeling very depressed.
12. When I am upset, I have difficulty focusing on other things.
13. When I am upset, I feel ashamed at myself for feeling that way.
14. When I am upset, I feel guilty for feeling that way.
15. When I am upset, I have difficulty concentrating.
16. When I am upset, I have difficulty controlling my behaviors.
17. When I am upset, I believe that wallowing in it is all I can do.
18. When I am upset, I lose control over my behavior.

Appendix D: AAS Questionnaire Revised (Collins, 1990)

The following questions concern how you ***generally*** feel in ***important close relationships in your life***. Think about your past and present relationships with people who have been especially important to you, such as family members, romantic partners, and close friends. Respond to each statement in terms of how you ***generally*** feel in these relationships.

Please use the scale below by placing a number between 1 and 5 in the space provided to the right of each statement.

1--------------2--------------3--------------4--------------5

Not at all characteristic of me ... **Very characteristic of me**

1) I find it relatively easy to get close to people. ________
2) I find it difficult to allow myself to depend on others. ________
3) I often worry that other people don't really love me. ________
4) I find that others are reluctant to get as close as I would like. ________
5) I am comfortable depending on others. ________
6) I don’t worry about people getting too close to me. ________
7) I find that people are never there when you need them. ________
8) I am somewhat uncomfortable being close to others. ________
9) I often worry that other people won’t want to stay with me. ________
10) When I show my feelings for others, I'm afraid they will not feel the same about me. ________
11) I often wonder whether other people really care about me. ________
12) I am comfortable developing close relationships with others. ________
13) I am uncomfortable when anyone gets too emotionally close to me. ________
14) I know that people will be there when I need them. ________
15) I want to get close to people, but I worry about being hurt. ________
16) I find it difficult to trust others completely. ________
17) People often want me to be emotionally closer than I feel comfortable being. ________
18) I am not sure that I can always depend on people to be there when I need them.________

Appendix E: Math Questions

Adopted from Thorson and West (2018).

1. 30 X 31
2. 19 X 17
3. 28 X 20
4. 48 X 13
5. 20 X 21
6. (12/96) + (3/6) + (17/18)
7. 35 X 12
8. 28 X 30
9. (8/20) + (3/6) + (14/20)
10. 12 X 60
11. (15/31) + (10/62) + (11/62)
12. 21 X 18
13. 1870/34
14. (6/13) + (5/26) + (7/26)
15. 62 X 58
16. 12 X 56
17. 26 X 24
18. 30 X 12
19. 7964/44
20. 848/53
21. 38 X 39

22. 50 X 16

Appendix F: Interpersonal Play Exercises

Catch phrase or “taboo”: each participant in the dyad will be provided with a different list of words. Alternating one minute at a time, participants will provide clues to their partner, trying to get them to accurately guess the words on the list in successive order.

Say the Same Thing: this game starts with each participant counting down from three. Once “three” is reached, each participant states a noun/topic/idea. After that, participants conduct successive three-counts. After each count both participants say something at the same time. The goal is for both participants to say the same thing at the same time.

Pictionary: Each participant will be provided with a different set of words, a small dry erase board and a marker. In 30-second intervals, participants will try to depict one of the words from their list. If their partner cannot correctly guess the word after the first 30 seconds of drawing, participants will then take another 30-second interval to re-draw or add to their drawing.