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Interactional Synchrony in Romantic Couples: Linking Dynamic Systems of Nonverbal Behavior with Outcome Data

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Interactional Synchrony in Romantic Couples:

Linking Dynamic Systems of Nonverbal Behavior with Outcome Data

A Dissertation Presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

Darren Jason Garcia

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Abstract

Interactional synchrony (i.e., dynamic patterns of coordinated movement) has been linked with prosocial constructs such as rapport, affiliation, empathy, and feelings of connectedness across a variety of naturalistic and experimental settings. The aim of this study was to bridge the growing body of research on interactional synchrony with variables reflecting relationship quality in romantic couples. Video data from 116 committed romantic couples who participated in a short-term, community-based relationship intervention (Gordon et al., 2019) and their self-report assessments of relationship satisfaction, emotional intimacy, and constructive communication patterns were used for analyses. First, simple motor movement was objectively quantified for each partner using Motion Energy Analysis (MEA; Ramseyer & Tschacher, 2011), an automated frame-differencing method that captures changes in video pixilation. Next, cross-lag correlations of the time-series data were aggregated and operationalized as interactional synchrony. Associations between interactional synchrony and relationship quality variables were examined.

Results demonstrated that interactional synchrony positively predicted relationship satisfaction at baseline, 1-month and 6-months post-intervention. Interactional synchrony predicted emotional intimacy at baseline and 1-month post intervention; however, it only predicted constructive communication at baseline but not at 1-month post intervention. The presence of interactional synchrony was not stronger in affiliative conversations (discussion of courtship story and relationship strengths) relative to contentious conversations (relationship concerns), which suggests that happy couples may be able to maintain synchrony even during difficult conversations. Interactional synchrony did not predict increases in the aforementioned relationship quality variables at any of the timepoints.

Overall, results suggest that interactional synchrony is linked with indicators of relationship quality in romantic couples, does not vary based on conversational context, and does not predict changes in satisfaction, emotional intimacy, and constructive communication in a short-term intervention. Pending further research, results indicate that interactional synchrony may serve as an objective, relatively stable indicator of romantic couple relationship quality that might be considered in addition to self-report assessments.

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Humans have evolved patterns of coordinated behavior that facilitate social bonds and feelings of solidarity with others (Oullier, De Guzman, Jantzen, Lagarde, & Kelso, 2008; Tarr, Launay, & Dunbar, 2014). For example, chanting in tribal unison, synchronized drumming during a ceremonial ritual, singing a fight song on a college campus, and dancing are all examples of coordinated behavior that reflects a sense of social connectedness, unity, or "togetherness." Contemporary research (e.g., Launay, Tarr, & Dunbar, 2016; Lang, Bahna, Shaver, Reddish, & Xygalatas, 2017; Tarr, Launay, & Dunbar, 2014; Van Baaren, Holland, Kawakami, & Van Knippenberg, 2004) has shown that these various ways of "keeping together in time" (McNeil, 1997) tend to materialize in our neurobiological substrates (e.g., in oxytocin and the dopaminergic system) during cooperative social interactions and human bonding experiences.

As Fishbane (2013) has put it, humans are "wired for connection" (p. 59). Positive socioemotional development and secure attachments during infancy and early childhood are reflected in the coordination of nonverbal behavior with caregivers (Isabella & Belsky, 1991), which is particularly the case during early development (Tronick & Gianino,1986; Tronic, 1989, Beebe et al., 2016; for a review, see Stern, 2018). Moreover, some of the most influential psychological theories of development, such as interpersonal theory (Stack-Sullivan, 1953) and attachment theory (Bowlby, 1977), for example, begin with the premise that, for humans, the quality of emotional life is grounded in interpersonal interactions. In other words, the affective quality of our experience develops in accordance with the contingent behavioral and emotional signals we receive, which depends in no small part on our ability to socially attune and respond

to the verbal and non-verbal behavior of others. However, neither attachment theory nor interpersonal theory adequately addresses the import of patterned, simple motor movements (i.e., temporal and spatial behavioral coordination) in the context of interpersonal interactions. The role of simple motor movement in healthy romantic relationships might be considered, as Rosenbaum (2005) put it, "The Cinderella" of psychological research on relationships; indeed, the role of coordinated body movement in the study of romantic relationships is a largely neglected and underappreciated area of research.

Coordinated Movement in Romantic Relationships

What role does coordinated movement play in committed romantic relationships? This is the broad conceptual question that guides the present study. Condon and Ogdon (1966, 1967) were among the first scholars to empirically study and observe how humans tend to rhythmically coordinate their verbal and nonverbal behavior during social interactions. Using cinematography techniques, they observed that speakers rhythmically coordinated various parts of their bodies with their own speech, and the listeners synchronized their simple motor movements to the movement and speech of their interaction partners (Schmidt & Fitzpatrick, 2016). Dance is a fitting example of how the dynamic, subconscious, and often habitual movement of an interacting partner can influence one's own movement and subjective judgments (e.g., "that was a great dance!"). This raises the question of whether movement, specifically coordinated motor movement, can influence subjective judgements in the context of committed romantic relationships.

In considering dance as an example, one sees that the concept of coordinated movement can subsume various types of synchronous behaviors; these can be further differentiated in terms of verbal (e.g., I ask for this dance) and non-verbal (e.g., you walk onto the floor) behaviors, as

well as sequential (e.g., after I do this step you do that step) and simultaneous (e.g., both partners do the same dance step at the same time) behaviors. Indeed, those who dance at an intermediate or advanced level conceptually understand that coordinated movement often relies on an element of improvisation, meaning that one person often starts a step, changes direction, or mirrors their partner's step based on the subtle movements of their dance partner (for a review, see Ribeiro & Fonseca, 2011). This complex dynamic sequence requires that each partner adjust and readjust their own movement per the bodily information they attune to and perceive from their partner's movements (Pietrzak, Hauke, & Lohr, 2017). Indeed, successful dance requires a high level of spatial awareness and socioemotional attunement to the nonverbal movements of those with whom one interacts.

Not accidentally, dance has served as a productive metaphor that couple therapy researchers and theorists have used to capture the mutual influence of each partner in maintaining specific patterns of interpersonal communication (Christensen, Doss, & Jacobson, 2014; Johnson, 2004). For example, take these two different evidence-based couple therapy models: Emotionally Focused Therapy for couples (EFT; Greenburg & Johnson, 1988) and Integrative Behavioral Couples Therapy (IBCT; Jacobson & Christensen, 1998). EFT attempts first to illuminate the couple's negative "interactional dance" (Johnson, 2004), meaning that there are systemic patterns of interaction that have become ritualized and problematic. For example, a typical negative interaction is when Partner A demands a specific behavioral change of Partner B, but Partner B does not engage and instead withdrawals from the interaction. To address these negative interactions, the EFT therapist typically encourages the couple to engage with one another directly (*enactments*) to reorganize their typical patterns or "interactional dance" (Johnson, 2004). This is accomplished by restructuring the couple's moment-to-moment

verbal and nonverbal interactions. For example, the EFT therapist might say, "will you turn to her and tell her…" (Johnson & Greenman, 2006, p. 603- 608). In this sense, the EFT therapist grounds the couple's emotional experience in the dynamic interaction between them. Importantly, promoting responsiveness between partners in this way is a key objective for the EFT therapist. Indeed, a precise aim of EFT is to improve empathic understanding by promoting emotional engagement between partners. However, in EFT the primary treatment focus is usually the verbal interaction rather than the nonverbal dynamics.

Similarly, in the IBCT treatment model, there are numerous examples in which scholars use the metaphorical language of dance to describe the interpersonal communication patterns of the couple (Christensen, Doss, & Jacobson, 2014, p. 10-12, 101-112, 184-188). The couple therapy literature is notably rife with the word "avoidance," which etymologically means to evade or avoid movement. In IBCT, a key intervention for rebuilding couple interaction and emotional engagement is *empathic joining*, an intervention believed to promote intimate safety and, therefore, empathic understanding and acceptance (Christensen, Doss, & Jacobson, 2014). At the heart of both EFT and IBCT is the critical importance of building within each partner the capacity for engagement, empathic responding and thus emotional intimacy (Hawrilenko, Gray, & Córdova, 2016). Both of these approaches are enactive in that the therapist observes and connects the couple's interactions and directs their moment-to-moment interactions toward each partner's inner emotional experience. However, the spatiality and temporal sequencing of the behavioral interactions between partners (i.e., the role of patterned and rhythmic movement) has not received serious empirical consideration in either approach.

Although the dance-like nonverbal communication between the couple is clearly important and presumably noticed by the therapist, at least implicitly, the nonverbal behavioral

dynamics surrounding such interventions are rarely explicitly measured in contemporary couple therapy research (for some exceptions, see Gottman, 1994, 2005; Gottman & Porterfield, 1981). Bodily signals may reflect key indicators of couple therapy processes and outcomes. Shuper-Engelhard and Vulcan (2018), for instance, have argued that the integration of body movement in couple therapy through dance improves empathic responding and is gaining traction as a viable couples intervention (see also Dance Movement Psychotherapy for couples [DMP-C]; Lacson, 2020; Shuper-Engelhard, 2019b). Nonetheless, with the exception of studies examining DMP-C in typically nonclinical settings, research examining the role of coordinated body-movement in romantic couple relationships has been relatively absent in the scientific literature. This is all the more surprising considering how several couple relationship problems involve bodily communication (e.g., dominating physical space, physical aggression, physical withdrawal), in addition to the verbal modes of communication that are frequently studied and focused on in couple therapy (Snyder, Castellani, & Whisman, 2006).

The role of bodily communication in couple therapy research has largely been limited to the study of isolated nonverbal expressions as behavioral indicators of emotional states or therapy outcomes; there has been very little focus on the dynamic systems of movement that couples create as part of an enactive process. Gottman (1994), for example, notoriously demonstrated that eye-rolling, an indicator of contempt, is one of the best-known predictors of relationship dysfunction. However, it is certainly possible that the eye-rolling itself is never even seen by one's partner or is perhaps a playful gesture rather than a contemptuous act. In this sense, the dynamic unfolding of the behavioral interactions that comprise eye-rolling on the part of one partner may, in fact, be just as important as the isolated significance of eye-rolling itself. Along these lines, many contemporary couple therapy researchers, including Gottman (2005),

have called for a more dynamic (non-linear) investigation of the patterns that emerge in couple relationships, yet there remains a need for empirical researchers to heed the call.

Despite deep roots in systemic theory (see Minuchin & Nichols, 1998), couple therapy research generally lacks a dynamic systems perspective that includes the role of nonverbal behavioral synchrony. Applying dynamic systems theory to the study of coordinated motor movement in romantic couple relationships may potentially improve the knowledge base of couple and family science. Thus, I elaborate on the importance of dynamic systems theory; indeed, an understanding of dynamic systems is critical for conceptualizing interactional synchrony from an embodied cognition perspective.

Interactional Synchrony, Embodied Cognition, and Dynamic Systems Theory

The interdisciplinary study of interactional synchrony has emerged alongside the embodied cognition movement (Hauke & Kritikos, 2018). Embodied cognition scholars (Fuchs & Koch, 2014; Varela, Thompson, & Rosch, 2016) deviate from the traditional premises of representationalist theories of cognition and structuralist theories of emotion and argue, instead, that the brain is not our only cognitive resource. Rather, they argue, "the *body* is a co-designer of mental processes" (emphasis added; Hauke & Kritikos, 2018, p. vii). Embodied cognition scholars move beyond standard cognitive science and argue instead that the mind and body are mutually constituted and inextricably connected to the environment and feeling states of others (Fuchs & Koch, 2014). Fuchs (2009) nicely sums up the claim of modern embodiment research: "The mind is not in the brain; it is not located in any one place at all, but is rather distributed among the brain, the body, and the environment" (p. 221). The implication is that perception and brain-behavior relationships are more contextually situated in moment-to-moment interactions between active agents than cognitive processing metaphors would suggest.

Further, an embodied social cognition is considered enactive; that is, organisms do not passively receive information from the environment and translate it into neurochemicals or internal representations; rather, organisms are active agents in the generation of meaning as it unfolds in their moment-to-moment interactions. From an embodied cognition perspective, then, we actively use our bodies to consolidate sense-making, as well as infer our connectedness with others. Perception is not solely guided by stimulus-response patterns or internal emotions, rather, the phenomenology of the emergent interactional processes in conjunction with neurobiological activity guides perception and thus behavioral possibilities. As a contrast, consider how in EFT, emotion holds primacy and is "the music of the couple's dance" (Johnson, 2015, p. 98), whereas, from an embodied cognition perspective, on the hand, neither behavior nor emotion can be considered primary because they are mutually constituted and inseparable. In short, we use a wide bandwidth of bodily signals (internal, external, conscious, and non-conscious) to consolidate our perceptions during interpersonal interactions. Debating whether emotional or cognitive variables hold primacy, without considering the contextual situatedness of the interaction itself has led to serious rifts among scholars (Lazarus, 1982 ct. Zajonc, 1980; see also Lazarus, 1999). The investigation of interactional synchrony in romantic dyads necessitates a dynamic systems approach that considers intersubjective phenomena (Gottman, 2005).

From a dynamic systems theoretical perspective, social understanding between romantic partners emerges in the nonlinear interaction and coordination of two or more embodied persons (Fuchs & De Jaegher, 2009, p. 465). In this view, the feeling of connection or solidarity between romantic partners emerges not solely from an area of the brain or body but arises in the interaction process itself—in the moment-to-moment interactions of the couple as they engage with one another. This dynamical approach draws extensively on Merleau-Ponty's

phenomenological concept of *intercorporeality* or mutual incorporation—that is, lived bodies of interaction partners (e.g., romantic partners) are mutually constitutive (Dreyfus & Dreyfus, 1999). Mutual constitution, in this sense, means that ideas about one's partner contributes to the very nature of one's own identity or subjective self-understanding. In terms of romantic couple relationships, for example, one cannot be considered a good partner in insolation—the quality of the relationship enactively emerges in relationship, requiring both partners. Embodied cognition reflects a non-dualist theory of how cognition and perception about one's relationship emerges in the relationship itself.

Lewin (1951) argued that to understand human behavior the proper subject of study was not merely the individual but the *lifespace* (social whole). For Lewin, the best way to understand personality or individual characteristics was in relation to the holistic context, including interactions with other people. Drawing on this idea, Aron, Aron, Tudor, and Nelson (1991) developed a relational model of cognition in which individuals are motivated to engage in relationship as a form of self-expansion. In an early study, Aron et al. (1991) found in a series of three experiments that material resources, perspectives, and descriptive characteristics tend to merge as a result of perceived self/other overlap. Following the development of the Inclusion of Other in the Self (IOS) scale (Aron, Aron, & Smollan, 1992), where participants use overlapping circles (self/other) to depict the closeness of their relationship, a number of empirical studies have shown that the degree of self/other overlap interacting partners perceive is correlated with first person plural language ("we" and "us"), feelings of closeness, and empathic behavior (for a review, see Aron, Norman, & Aron, 2002).

Dynamic systems involve the coupling of self-organizing principles (e.g., internal arousal and emotion regulation) and entrainment to the dynamics of others (e.g., one partner

withdrawing when the other is angry)—both of which are influenced and influenced by the other partner in moment-to-moment interactions. Coming from a dynamic systems vantage point, Sameroff (1983, 2010) noted that self-regulatory activity and other-regulatory activity are intimately related and should, therefore, be considered elements of a single system. More specifically, a dynamic systems perspective must take into account not only how one is affected by their internal feelings and behavior, but also how they are affected by their perception of the manifest behavior and feelings of their romantic partner in the moment-to-moment interactions between them (Thomas & Malone, 1979; Thomas & Martin, 1976). As such, individual characteristics and behaviors are part of the system, but the system is also greater than the sum of its parts. Thus, it is important to note that, at the individual level, there may be differences with regard to the amount of closeness or intimacy one or both partners desire, which may affect their interactional synchrony. If one partner is reluctant to or incapable of engaging with the other it will, of course, affect the whole system.

Scholars in a wide variety of disciplines who study interactional synchrony (for a reviews, see Hauke & Kritikos, 2018 and Passos, Davids, & Chow, 2016) often apply different terms to communicate their construct of interest (e.g., nonverbal synchrony, interpersonal synchrony, interpersonal coordination, behavioral mimicry, behavioral synchrony, movement mirroring, and interactional synchrony), which can at times be confusing. Therefore, it is worth noting that the aforementioned labels (and many others) mainly differ along the dimensions of timing and the voluntary imitation of specific behaviors. Interactional synchrony in the present study was conceptualized as a dynamic process whereby committed romantic couples mutually coordinate their nonverbal behavior in reciprocal moment-to-moment interactions.

Empirical Research Investigating Interactional Synchrony

Babad, Bernieri, and Rosenthal (1991) defined interactional synchrony as the degree to which the behaviors of two or more people in an interaction are nonrandom, patterned or synchronized in both form and timing, a conceptual definition that captures well the construct of interactional synchrony as it was used in the current study. Interactional synchrony subsumes both *behavioral mimicry* (i.e., the linear imitation of specific behaviors) and *interpersonal synchrony* (i.e., how another's behavior affects our own). Whereas behavioral mimicry refers to imitating another's specific behavior and thereby entails a linear relationship, interactional synchrony refers to instances in which the movements of two or more people are coordinated and overlap in time (Bernieri, Reznick, & Rosenthal, 1988). For this study, I used the more theoretically inclusive term, *interactional synchrony*, in order to capture the dynamic reciprocation of body of movements between interactive partners over time (Delaherche et al., 2012).

Although interactional synchrony has been studied as it relates to the coordination of verbal, affective, and nonverbal behavior, in this study I refer to interactional synchrony only in terms of the coordination of simple motor movements (i.e., nonverbal behavioral synchrony) between romantic partners. In studying interactional synchrony in the context of couple romantic relationships, I emphasized the coordinated behavior between partners as an enactive and responsive process between committed romantic partners, rather than the nature of the discrete behaviors (i.e., behavioral matching or imitation). Indeed, interactional synchrony, as it is conceptualized in the present study, may be conceptualized as a behavioral, nonverbal manifestation of socioemotional attunement and reciprocal responsiveness that emerges between committed romantic partners.

Research investigating the role of mirror neurons has shown that perceived movement plays a key role in social understanding and empathic responding (Cattaneo & Rizzolatti, 2009; De Jaegher, & Di Paolo, 2007) as well as compassion (Valdesolo & Desteno, 2011), and these findings have been replicated in numerous studies (see e.g., Hove & Risen, 2009; Wiltermuth & Heath, 2009; Tarr, Launay, Cohen, & Dunbar, 2015; Cohen, Esmond-Frey, Knight, & Dunbar, 2010). For this reason, in addition to studying verbal indicators of empathy, some romantic couple researchers (Fischman, 2015; Jola, 2010; Pietrzak, Hauke, & Lohr, 2016; Shuper-Engelhard, 2019a) are beginning to merge cognitive neuroscience with choreography and demonstrating that interactional synchrony may reflect a type of "kinesthetic empathy." The idea that the embodied simulation of movement plays a crucial role in the expression and understanding of empathy during interpersonal interactions (Rizzolatti, Fadiga, Fogassi, & Gallese, 2002) has been supported in both behavioral and neuroscience research on the role of movement in empathic responding.

Similarly, Gallese's (2009) shared manifold hypothesis, which holds that the body is the central information source in understanding the intentions of others, has garnered empirical support for the idea that the mirror neuron system plays a key role in enabling empathy. Lang, Bahna, Shaver, Reddish, and Xygalatas (2017) found that interactional synchrony between unacquainted dyads activates endogenous opioids that mediate the relationship between interactional synchrony and ratings of liking and trust in the context of cooperative tasks. More recently, Mogan, Fischer, & Bulbulia (2017) compiled meta-analytic evidence suggesting that synchronous behavior is associated with the release of endogenous endorphins (dopamine and oxytocin) involved in human bonding and emotional intimacy (see also Hale & Hamilton, 2016; Launay, Tarr, & Dunbar, 2016; Tarr, Launay, & Dunbar, 2014). Notably, in these healthy non-

clinical samples, Mogan et al.'s (2017) review of 42 independent experiments found positive medium effects for behavioral synchrony on subsequent prosocial behavior, with small to medium effects on both social bonding and social cognition, and small effects for synchrony on positive affect. Notably, in the context of romantic couples, Fishbane (2007, 2013) has documented how oxytocin and the dopaminergic system are highly active in committed couples with a high level of trust, empathy, and intimacy. While the exact mechanisms are still being investigated, the neurobiological evidence showing a connection between empathy and perceived movement is growing.

Behaviorally, Chartrand and Lakin (2013) reported that spontaneously mimicked behaviors (e.g. postures, facial expressions, mannerism, and gestures) are the "social glue" that binds interaction partners together. Some experimental studies (see e.g., Cacciopo et al., 2014; Oullier et al., 2008) have demonstrated a causal link between interactional synchrony and prosocial behavior (for a review, see Vicaria & Dickens, 2016). Baaren, Holland, Kawakami, and Knippenberg (2004) experimentally induced behavioral mimicry in a series of three studies and found that behavioral mimicry increased helpful behavior not only toward the confederate but also towards the experimenter following the experiment (e.g., picked their pen up for them more frequently in the mimicry condition). Bridging these lines of research, it seems quite plausible that interactional synchrony may play a key role in the development and maintenance of healthy romantic couple relationships. Nonverbal synchrony is not only associated with social bonding (e.g., liking, empathy, cooperation, helpfulness), but the prosocial effects of interactional synchrony appear to extend beyond the immediate situation to subsequent interpersonal interactions (Kirschner & Tomasello, 2010; Reddish, Bulbulia, & Fischer, 2014; Schmidt, Morr, Fitzpatrick, & Richardson, 2012). Vicaria and Dickens's (2016) meta-analysis

documented several experimental studies that manipulated synchronous behavior and observed increases in subsequent prosocial behavior. Taken together, these results suggest that individuals in romantic relationships may feel more connected to and act more positive toward their partner after experiencing interactional synchrony with their partner. However, considering how there is very limited research pertaining to interactional synchrony in couple romantic relationships, and research showing that development of interactional synchrony begins in the context of early relationships (Leclère et al., 2014), it is difficult to gauge directional causality, as well as measure the extent to which interactional synchrony in couple relationships reliably changes.

Furthermore, early theoretical work by Beebe (1986) showed that mother-infant interactional synchrony was related to social attunement, reciprocal social behavior, positive parenting practices, and better socioemotional development for the child. Not dissimilar to how interactional synchrony is conceptualized in the current study, the mutual influence of mother and child was conceptualized as "alternating stimulus-response sequences as well as simultaneous synchronizations" among the dyad pairs (Beebe, 1986, p. 31). Contemporary research (Feldman, 2007; 2012; Harrist & Waugh, 2002; Stern, 2018; Tronick, 1989; Tronick & Gianino, 1986) suggests that the dynamic caregiver-child interaction lays the foundation for social attunement and later prosocial behavior. In their review, Leclère et al. (2014) highlighted how mother-child interactional synchrony is associated with familiarity, a healthy mother, typical development, and more positive cognitive and behavioral outcomes among children (see also Stern, 2018).

However, despite a well-established literature linking interactional synchrony between infants and caregivers with multiple domains of social functioning, there remains much to be understood in regard to coordinated movement in the context of romantic couples. Since

Tronick and Gianino's (1987) early work demonstrating that positive psychological development can be predicted from early infant-caregiver bidirectional contingency sequences, a number of studies have documented the critical role of both *intra*-personal and *inter*-personal coordination (see e.g., Beebe et al., 2016), which may lay the groundwork for empathic responding and thus the capacity for engaging in close relationships. Conversely, a lack of interactional synchrony has been documented as a marker for of psychological distress (Paulick et al., 2018) and identified as a marker for the presence of some mental disorders (e.g., Lavelle, Healey, & McCabe, 2012; Marsh et al., 2013)

Interactional Synchrony and Disorders with Social Attunement Deficits

Some neurodevelopmental disorders, particularly those characterized by deficits in social attunement and socioemotional awareness (e.g., autism and schizophrenia), reflect a lack of interactional synchrony (Kupper, Ramseyer, Hoffmann, & Tschacher, 2015). Lavelle, Healey, and McCabe (2012) showed that in interactions with patients with schizophrenia nonverbal communication is frequently disrupted (see also Varlet et al., 2012). Likewise, in patients with autism spectrum disorder, another disorder associated with social attunement deficits, asynchronous movement is particularly prominent (Marsh et al., 2013; Trevarthen & Delafield-Butt, 2013). From a dynamic systems perspective, interactional synchrony is created within the dyad and requires both partners; however, when one interaction partner lacks the ability to attend to or engage in the interaction, the whole system may be disrupted. Indeed, interactional synchrony may reflect an underlying latent process by which social connections are made and maintained (Tarr, Launay, Cohen, Dunbar, 2015). Notably, this supposition does not mean that individuals who are unable to socially connect are necessarily at risk for mental illness. Rather, on the whole, these findings suggest that individuals who present with mental disorders

characterized by a lack of social attunement and impaired behavioral responsiveness often demonstrate deficits in interactional synchrony.

Galbusera, Finn, & Fuchs (2016) used advanced automated methods to explore whether increases in synchronous movement between therapists and patients with schizophrenia would be related to improved therapy outcomes. Over thirteen sessions of body-movement psychotherapy (BMP), they found that increases in interactional synchrony in these patients were associated with a decrease in negative symptoms, which are notably the most difficult of symptoms to treat in patients with schizophrenia. The most significant aspect of this study is that it demonstrated that embodiment techniques promoted synchronous movement, which in turn improved therapy outcomes. This finding potentially provides causal support for the role of nonverbal synchrony in the experience of interpersonal connectedness and improved therapy outcomes. In the context of romantic couples, a lack of interactional synchrony may likewise mark low social attunement in one or both partners or difficulty engaging in intimate relationships.

Interactional Synchrony and Therapy Processes and Outcomes

A growing body of research has begun to demonstrate the positive association between interactional synchrony and therapy outcomes. For example, Ramseyer and Tschacher (2011) demonstrated that nonverbal synchrony is positively related to client reports of therapeutic alliance and the client's reported self-efficacy. In this methodologically rigorous study using, the authors used Motion Energy Analysis (MEA), an objective frame differencing algorithm to examine nonverbal synchronous movement in video-taped cognitive behavioral therapy sessions of 104 therapist-patient dyads. Self-reported psychopathology at termination was lower in therapeutic dyads manifesting higher levels of nonverbal synchrony relative to baseline nonverbal synchrony. They also found modest support for their hypothesis that nonverbal

synchrony was related to rapport between the therapist and the patient, suggesting that interactional synchrony may be a process variable with broad implications for therapeutic interventions.

As most couple therapy practitioners can attest, the couple's ability to socially attune to and emotionally engage with one another is essential for subsequent positive interactions (Johnson, 2004). Early work (Gottman & Porterfield, 1981) demonstrated that husbands who were able to read their wives' non-verbal cues had more satisfied wives than husbands who could not. However, it is important to note that although one partner's response might change the dynamic, synchronous interaction is a systemic variable that is grounded in dynamic systems theory and embodied cognition. From this framework, as Lewin (1951) argued early on, properties of an individual cannot be properly understood in isolation from their partner but as a social whole. Moreover, Galbusera, Finn, Tschacher, and Kyselo (2019) investigated the impact of interpersonal synchrony on the stability of self-regulation and found that interpersonal synchrony predicted a reduction of self-regulation of affect, suggesting that there is much to learn about the dynamic interplay between intra- and inter-personal synchrony.

Additionally, embodiment research points to the idea that cognitive processes can be rigorously studied in conjunction with bodily processes (Varela, Thompson, & Rosch, 2016). In a qualitative study examining romantic couples' reasons for participating in a form of Body Movement Psychotherapy (BMP) for couples, Shuper-Engelhard and Vulcan (2018) found a common theme among the nine couples who participated was their desire to "learn a new mode of communication through the body," which they felt was absent in their verbal communication. The couples reported that they developed insights about their relationship by focusing specifically on bodily communication. In addition to verbal communication patterns, researchers

(Behrends, Müller, & Dziobek, 2016; Shuper-England, 2019a, 2019b; Lacson, 2020) have found that by focusing on improving bodily coordination through dance empathic responding in romantic couples improves.

In a qualitative study of Dance Movement Psychotherapy (DMP) and couple relationships, Kim, Kang, Chung, and Park (2013) showed that inducing movement by asking partners to choreograph their most memorable moments and to engage in structured activities (dancing the cha-cha) aimed at enhancing kinesthetic empathy, synchronized movement was associated with increased emotional attunement and empathy in both partners (see also Behrends, Müller, & Dziobek, 2016). Furthermore, in an innovative qualitative study from an embodied cognition perspective, Pietrzak, Hauke, and Lohr (2016) found that for couples in which one partner was diagnosed with borderline personality disorder, embodiment principles improved mutual social attunement, empathic understanding and relationship satisfaction. More specifically, having each dyad engage in a choreographed solution to their closeness/distance theme enhanced mutual understanding. However, in qualitative analyses one cannot rule out whether and how much kinesthic empathy was present prior to the activities. Nevertheless, studies that move beyond traditional verbal interventions to alleviate marital discord, although in their infancy, reveal the practical implications that may be drawn from empirical work aimed at improving the kinesthetic components of empathy, such as interactional synchrony, in addition to more verbally-based interventions that merely focus on verbal modes of communication.

Furthermore, there may be some contexts in which synchronous movement may have more negative implications. For example, in some physiological studies of romantic couple relationships, too little or too much synchrony has been associated with poorer relationship satisfaction (Coutinho et al., 2019). One could conceivably imagine a boxing match or other

competitive task in which interactional synchrony could be present in abundance, yet not positively associated with outcomes typically linked with synchrony (rapport, empathy, responsiveness). However, except for a few studies examining synchrony in affiliative versus more competitive contexts (Bernieri, Gillis, Davis, & Grahe, 1996; Paxton & Dale, 2013), research investigating the contextual effects of interactional synchrony are scant. Tschacher, Rees, and Ramseyer (2014) found that synchrony in the competition condition was associated with significantly higher negative affect than the fun task condition, whereas the cooperation and the fun task conditions were not statistically different, suggesting that synchrony may have more positive implications in some contexts versus others. Nevertheless, in contexts where the outcome of interest relates to emotional or affective connection of some sort, increases in nonverbal synchronous movement likely reflect emotional engagement, social attunement, and behavioral responsiveness (e.g., Shuper-Engelhard & Vulcan, 2018); these underlying factors may be critical for relational health despite the affective valence of the interaction. However, research specifically examining the effects of synchrony during interactions that are more negative by nature (e.g., a fight) is generally lacking.

Some research has shown that conflictual situations disrupt interactional synchrony. In a sample of 64 unacquainted undergraduates, Paxton and Dale (2013) found that argument-based situations (i.e., discussion of a political topic on which they reported disagreement) disrupted spontaneous nonverbal synchrony in paired dyads (see also Bernieri, Gillis, Davis, & Grahe, 1996). While paired dyads in both the conflict and non-conflict conversation conditions demonstrated nonverbal synchronous behavior, they found that dyads who engaged in the argument-based conversation demonstrated a breakdown or attenuation of nonverbal synchrony while participating in the conflict condition. Notably, in the linear mixed models they employed,

the authors did not find an effect for positive affect on interactional synchrony. Because positive affect did not predict levels of interactional synchrony, they interpreted the result to mean that there is something more than affect at play when argument disrupts synchrony. This may include factors such as empathic understanding, social attunement, and engagement, regardless of whether such affect is positive or negative. This study lends support to the notion that interactional synchrony will be more pervasive during times of emotional bonding than during times of conflict. Interactional synchrony may play a unique role in facilitating emotional bonds during dyadic interactions that is not fully accounted for by affective factors. However, other research suggests that synchrony tends to precede positive affect.

Extending research on mimicry enhancing positive affect, Tschacher, Rees, Ramseyer (2014) also found that synchrony precedes positive affect during dyadic interactions of unacquainted same-sex dyads. Although they found that nonverbal synchrony positively predicted positive affect, unlike the results from Paxton and Dale's (2013) study, which showed that argumentative conversations disrupted behavioral synchrony, Tschacher and colleagues (2014) found that mildly competitive tasks actually elicited more synchrony than cooperative tasks. The authors did, however, find that the fun task elicited the highest levels of synchrony, which mirrored research by Bernieri, Gillis, Davis, and Grahe (1996), who found higher levels of synchrony and rapport when undergraduate participants were instructed to "plan a trip around the world" versus the debate context in which they were instructed to "persuade your debate partner that you are right." Taken together, these studies suggest more interactional synchrony will be present in affiliative versus conflictual conversations. However, in all of these studies, it is worth noting that participants were unacquainted dyads with no commitments to one another,

and it is unclear how interactional synchrony unfolds in committed romantic couples discussing real concerns in their relationship.

Interactional Synchrony and Romantic Couple Relationship Functioning

A limited number of studies have examined reciprocal interactions in romantic couples. For example, in 15-minute interactions with romantic dyads, Manusov (1995) had trained raters assess the synchrony of seventeen predefined behaviors subsumed under either affect (warmth) or vocal activity (loudness) and found overwhelming reciprocal, patterned interactions regardless of satisfaction level, but satisfied couples (DAS scores > 100) were less likely to reciprocate low involvement and negative affect and more likely to reciprocate positive affect. Conversely, Heyman (2001) documented that dissatisfied couples are more likely to reciprocate negative behavior than satisfied couples. More specifically, compared to non-distressed couples, distressed couples appear to return negative responses even when their partners respond with positive affect.

Moreover, there appear to be certain situations in which social and emotional engagement can escalate and heighten rather than downregulate negative affect (Levenson & Gottman, 1983, 1985). In conflictual interactions, internal or physiological synchrony between partners (e.g., sympathetic nervous system) has been associated with less relationship satisfaction, and the effect is strong, with physiological synchrony accounting for more than half the variance in relationship satisfaction in early studies (Levenson & Gottman, 1985). Further, in a more recent study, Coutinho et al. (2019) also found higher physiological synchrony (i.e., electrodermal activity; EDA) during negative interactions (relative to positive interactions). Levenson and Gottman (1983) noticed early on that physiological synchrony was stronger when couples discussed conflict-laden topics. In a recent review of literature of physiological synchrony in

couples, Timmons, Margolin, and Saxbe (2015) noted that moderate levels of physiological synchrony seem to be associated with higher marital satisfaction, but too much or too little synchrony may be potentially deleterious for romantic couple functioning. However, behavioral and physiological synchrony appear to function differently depending on the context. Although the interplay of physiological and behavioral synchrony is beyond the scope of this study, given how nonverbal synchrony (behavioral) is robustly linked with social bonding mechanisms and prosocial behaviors, the coordination of intra- and inter-personal dynamics in romantic couples warrants further exploration. Thus, the focus of this study is on the nonverbal rather than verbal behavioral dynamics in couple relationships, though verbal behavior is clearly important.

Research has demonstrated that satisfied couples exhibit more responsive body language during marital problem-solving discussions than dissatisfied couples. Julien, Brault, Chartrand, and Begin (2000) examined nonverbal synchrony as an outcome variable of couple therapy. They investigated 10 satisfied versus 10 unsatisfied marriages, divided by scores on the marital adjustment Test (MAT). Using observational coding, they looked at several variables (gaze and body-openness, body position) and found that in satisfied couples, the male partners' body openness was associated with changes in the female partners' body openness, and changes in the female partners' body-position was related to changes in gaze for their male counterparts (see also Julien, 2005 for procedural details). Although the authors found happily married couples exhibited more expressive coordinated body language, they did not find effects for simultaneous movement, which they examined separately with frequency counts using human raters.

It should be noted, however, that frame-differencing techniques for investigating continuous movement dynamics (e.g., Motion Energy Analysis; Ramseyer & Tschacher, 2011) to measure simple motor movements are relatively new. These automated methods allow for a

high level of reliability and sensitivity that may be necessary to detect system dynamics beyond those captured by observational coding. Kazdin (2006), a prominent proponent of evidence-based treatment, has raised criticisms regarding the "arbitrary metrics" of the field, and the limitations of self-report data are well-documented (Conway & Lance, 2010; Olson, 1977). Advanced behavioral imaging methods, such as those that will be used in this study, allow for more objective and precise measurement of movement dynamics, objectively grounding the relationship dynamics in manifest rhythmic and patterned behaviors, which is a methodological advantage of this study.

Although some research has shown that interactional synchrony in romantic couples at the intra-personal or physiological level (e.g., sympathetic nervous system or cortisol levels) may be a negative indicator of relationship quality, at the behavioral level coordinated non-verbal movement is generally linked to social bonding, rapport, liking prosocial behavior, positive affect, empathic responding and intimacy (see Vicaria & Dickens, 2016). However, studies that examine behavioral coordination typically investigate the construct with unacquainted dyads. Sharon-David, Mizrahi, Rinott, Golland, and Birnbaum (2018) extended previous research by manipulating interpersonal motor synchrony and examining the effects on positive affect (rapport) and constructs that reflect intimacy such as empathy and perceived responsiveness.

More specifically, across a series of four experimental studies, Sharon-David and colleagues (2018) manipulated interactional synchrony by asking undergraduate students to cycle synchronously or asynchronously while also disclosing an affect event or a neutral event and found that in the synchronous condition participants reported increased empathy and partner responsiveness, two key aspects of intimacy, and the effects were stronger in the affective disclosure condition. In their attempt to extend these findings to romantic couples, they

replicated their previous study by asking undergraduate participants to imagine that their romantic partner was cycling alongside them disclosing an intimate detail of their lives. They found in both studies (with strangers and an imagined romantic partner) that synchronous cycling during intimate disclosures instilled feelings of closeness indicative of intimacy, including empathy and perceived responsiveness. The authors concluded that in both groups (strangers and romantic partners), synchrony can induce a sense of closeness, leading to higher levels of self-reported rapport and intimacy compared to a non-synchronous control condition. However, a methodological limitation of this study is that it was done with undergraduate students where synchrony with one's romantic partner was not actually observed but imagined. Obtaining behavioral data with actual romantic couples during their interactions is a challenge in experimental research. The verbal components of romantic couple interventions have been well-studied theoretically and empirically; however, the kinesthetic (i.e., bodily) or simple motor components of empathy have simply not been well-studied in the context of romantic couple interventions.

In summary, whereas some research has shown that interactional synchrony in romantic couples at the intra-personal or physiological level (e.g., sympathetic nervous system or cortisol levels) may be a negative indicator of relationship quality, at the behavioral level, coordinated nonverbal movement is robustly linked to social bonding, rapport, liking prosocial behavior, positive affect, and other empathic responding and perceived intimacy (see Vicaria & Dickens, 2016). Thus, drawing on dynamic systems theory and embodied cognition perspectives suggesting that interactional synchrony may be a form of kinesthetic empathy, it is plausible that interactional synchrony may be related to theoretically meaningful constructs in couple relationships, such as commitment, emotional intimacy, and relationship satisfaction. Many

couple therapy interventions are aimed at improving emotional engagement and empathic responding, which in theory should improve emotional intimacy and thus positive interactions. The aim of this study is to investigate whether interactional synchrony, conceptualized as an indicator of social attunement, behavioral responsiveness, and empathic responding between interacting partners, is linked with romantic couple relationship quality.

Current study

As outlined above, contemporary research has shown that interactional synchrony may be a critical pathway leading to prosocial behavior and strong social and emotional bonds (Launay, Tarr & Dunbar, 2016; Oullier et al., 2008). However, nearly all of the previously discussed literature examined interactional synchrony in tightly controlled studies using primarily unacquainted dyads. Consequently, the import of interactional synchrony in everyday naturalistic contexts within authentic romantic relationships is virtually unknown. Because many of the underlying latent processes, such social attunement, empathic responding, and positive affective experiences are known to have import in romantic couple relationships, and these processes have likewise been theoretically and empirically connected to interactional synchrony, it seems plausible that interactional synchrony should be associated with indicators of relationship quality in romantic relationships.

Thus, the goal of this study was to investigate the role of interactional synchrony in committed romantic couples. More specifically, I honed-in on the processes and consequences of interactional synchrony at the nonverbal level of interaction between romantic partners using secondary data analysis of a therapeutic assessment intervention (Cordova et al, 2014; Gordon et al., 2019). The short-term relationship intervention from which these data were secondarily derived (Gordon et al., 2019) demonstrated small to moderate effects on key relationship health

outcomes (e.g., intimacy, positive communication, relationship satisfaction). Couples improved

on all these variables after a brief assessment. The assessment included discussion of the

couple's courtship story, relationship strengths, and concerns. Based on the aforementioned

research showing lower levels of synchrony in argumentative verses affiliative contexts (Paxton

& Dale, 2013), higher levels of interactional synchrony in the context of undergraduates

planning a vacation together versus when they discussed a contentious topic (Bernieri et al.,

1996) and the robust literature linking interactional synchrony to feelings of rapport and positive

affect (for a review, see Vicaria & Dickens, 2011), I expected higher levels of synchrony during

the couples' discussion of their courtship history and discussion of their relationship strengths

section than in the discussion of their relationship concerns, which is a more conflictual rather

than affiliative conversation.

This assessment portion of this intervention used motivational interviewing strategies

(Rollnick & Miller, 1995) and is modeled after IBCT's assessment protocol, which is designed to

have a therapeutic impact from the moment the therapist first encounters the couple (Jacobson &

Christensen, 1998, p. 59). Previous research has shown that this intervention increases positive

communication, emotional intimacy, and relationship satisfaction via the empathic joining of the

romantic partners (Christensen, Doss, & Jacobson, 2014; see also Hawrilenko, Gray, & Córdova,

2016). Given the robust literature suggesting that interactional synchrony, which some have

argued is a kinesthetic (i.e., bodily) indicator of empathy, predicts theoretically similar variables

of relational health (e.g., liking, trust, intimacy, empathy), it seems reasonable to suggest that

interactional synchrony may reflect a process-level variable that predicts positive relational

outcomes in romantic couples.

In this secondary analysis, I used existing self-report measures of relationship quality and automated observations of naturalistic interactions to examine the linkages between interactional synchrony and positive relationship outcomes. Specifically, I examined the following hypotheses:

Hypothesis 1: Interactional synchrony in romantic dyads will be positively associated with indicators of romantic relationship quality (communication, intimacy, relationship satisfaction) at baseline, 1-month, and 6-months (for satisfaction only) post-intervention.

Hypothesis 2: The level of interactional synchrony present will differ by conversation type (courtship story, strengths, and concerns), with less synchrony manifested in the discussion of relationship concerns than the discussion of the courtship story and strengths.

Hypothesis 3: Interactional synchrony over the assessment portion of the relationship intervention will predict increases in intimacy, positive communication, and relationship satisfaction, while controlling for baseline levels of relationship satisfaction, emotional intimacy, and constructive communication.

Method

Participants

All couples consented to participate in the short-term couple relationship intervention based on the Marital Check-up (Cordova, 2014). Participants in the current study were a subsample of large grant-funded study and were recruited via flyers, booths at community events, social media platforms, and third-party referrals. Couples who were in a committed cohabitating relationship, were over the age of 18, and did not present with extreme safety concerns involving physical or emotional harm were eligible for participation. Those couples who reported safety concerns were referred to community clinics with resources to optimally

treat these couples. The couples in this a sub-sample who met criteria for participation in this study 1) agreed to have their sessions video recorded and consented to have their video data used for research purposes, and 2) had video data that met minimal standards for frame differencing with motion energy analysis (MEA). Due to the methodological requirements of this study, 116 of the 263 couples who consented to have their video data were included in this study. See Table 1 in Video Inclusion Criteria section below for further details. Distributional characteristics of the convenience were not significantly different (See preliminary analyses in results section).

The current sample included 120 female participants (52%) and 112 male participants (48%). Of the 116 couples in this sample, 110 couples identified as heterosexual (95%), five couples identified as Lesbian (4%), and one couple identified as gay (1%). At baseline, 61% of the couples were married and 39% were cohabitating. Participants in the 25-30 age range made up the largest age group (33%), followed by 35-44 (29%), 45-54 (19%), 55 and older (10%), and 18-24 (9%). The racial makeup of the sample was 83% White, 16% African American, and less than 5% of the sample identified as either Native American, Asian, or Pacific Islander. Racial identification does not add up to 100% because participants were allowed to identify more than one race. In terms of ethnicity, only 3% of the sample reported their ethnicity to be Hispanic. The representation of Hispanic minorities was lower than in the original sample (8%), and representation of African Americans was slightly higher than in the original sample (16% ct. 8%). The racial and ethnic minority representation was similar to the original sample in all other respects and was generally representative of the Appalachian region from which the sample was drawn. In terms of economic status, 54% of the participants had an annual gross income that was less than $19,000 per year, 21% were in the $20,000 – $39,000 range, 14% were in the $40,000 – $59,000 range, 6% were in 60,000 – $79,000 range, and 5% reported earning over

$80, 000 per year. When considering combined income, 24 of the 116 couples (21%) were below the 2018 poverty threshold (below $16,460 combined income + $4,320 per child). With regard to parenting status, 52% of the sample had one or more children under the age of 18 living in the home.

Procedure

Relationship Intervention. The intervention portion of the program was completed in two sessions: assessment and feedback. In this study, only data from the assessment portion of the intervention was used, which included 1) a discussion of the couple's courtship story, 2) a discussion of relationship strengths, and 3) a discussion of relationship concerns. Per standard protocol of the intervention, each romantic partner picked out three strengths and three concerns before the facilitator (therapist) arrived at the couple's home or clinic setting in the community. After the facilitator engaged the couple in a discussion of how they met and what attracted them to each other (i.e. courtship story), the following question was asked:

> *"You picked_____, _____, and _____as the main strengths [weaknesses] in your relationship. Of these three, tell me about the one that stands out as your top strength [concern]."*

Using a motivational interviewing approach (Rollnick & Miller, 1995) and principles derived from Integrative Behavioral Couples Threapy (IBCT; Jacobson & Christensen, 1998; , while discussing the couples' strengths and concerns, the facilitator went back and forth between each partner with reflections and short follow up questions to encourage further dialogue, to get detailed perspectives from each partner. Each of these sections will be time-stamped and examined separately for nonverbal synchrony.

Video Inclusion Criteria. In general, there are several quality assurance checks with regard to whether videos are suitable for frame-differencing methods, because the properties of the video can affect the raw data that is generated. Ramseyer (2020) recently summarized the minimal standards for video frame differencing using Motion Energy Analyses (MEA). Generally speaking, MEA requires (a) a fixed camera position and stable settings (b) a static background devoid of external objects moving in or out of the video frame (c) a circumscribed region of movement in which no external objects including limbs of the interactant partner crosses over the defined region (d) stable lighting conditions with no gradual or abrupt changes or shadows (e) an adequate codec for digital recording and consistent hardware from video to video (see also Ramseyer & Tschacher, 2011).

The videos used in the present study are secondary data from a short-term relationship health intervention designed to improve romantic couples' relationship satisfaction and positive adjustment (Gordon et al., 2019). Some recordings took place in the participants home while others took place in a clinical setting in the community. Because these videos were originally intended for training purposes, the quality of the videos was highly variable. Due to the stringent inclusion criteria for frame differencing methods, random sampling from the larger study was not possible. Furthermore, in order to have sufficient power to examine the hypotheses of this study, the standards for quality assurance were relaxed to include videos met standards for 90% of the total duration of the video. With this caveat, video data that met inclusion criteria were available for 116 committed romantic couples ($N = 232$). Table 1 shows the reasons for which videos were excluded from analyses.

A few considerations regarding exclusion criteria are worth noting. First, the majority of the video recordings took place in the comfort of the participants home (64%). It is potentially

easier to achieve a high level of interactional synchrony in the comfort of one's own home compared to a clinical or experimental setting. Second, in order to have sufficient power to examine these hypotheses it was necessary to include the caveat that videos had to only meet inclusion criteria (Ramseyer, 2020; Ramseyer & Tschacher, 2011) for at least 90% of the duration of the full video. It is worth noting, however, that the mean synchrony scores and standard deviations of this sample are strikingly similar to those obtained in more controlled studies using demographically similar populations (ct. Ramseyer and Tschacher, 2011 [M = .113, SD = .017]), which lends some support to the reliability of measurement in the current study, despite using a convenience sample and videos not originally intended for use with MEA analyses. Nevertheless, this raises the possibility that experimental artifacts in the data are more likely compared to experiments with strong experimental control that are able to follow standard procedures per recommendations. Finally, the primary reason for which videos were excluded from MEA analyses was couples sitting too close together. The idea that couples who sit closer together and/or display physical contact may be more satisfied and experience more intimacy may be a serious confound (Jakubiak & Feeney, 2017). For example, the results of this study cannot rule out the possibility that sitting in close proximity to one's partner may in fact be more telling than the effects of interactional synchrony.

Data Preparation. Videos were time-stamped at the beginning and the end of the relationship strengths, and relationship concerns sections for each partner. This included a total of eight timestamps (two for Partner 1's relationship strengths and two for Partner 2's relationship strengths, two for Partner 1's relationship concerns and two for Partner 2's relationship concerns). The discussion of the courtship story was not timestamped separately for each partner. After the videos were timestamped, the duration between each timestamp was

converted to seconds and multiplied by the number of frames processed per second (29.97003), yielding start and stop points for each type of conversation in the video-frame. To allow the couple to settle in, frame differencing for the courtship story began at 300 frames in (approximately 5 seconds into the video) and ended just prior to when the first partner began discussing their relationship strengths. The strengths conversation was marked from this point to when the conversation about relationship concerns commenced. Finally, the discussion of concerns ended after discussion of both partners' concerns were discussed.

Motion Energy Analysis (MEA). Advances in video technology over the past two decades have facilitated a more objective quantification of movement in automated video recordings (Kupper, Ramseyer, Hoffman, Kalbermatten, & Tschacher, 2010; Paxton & Dale, 2013; Ramseyer, 2020). Motion energy analysis (MEA) is a method that uses frame-differencing techniques to analyze pixilation changes in particular regions of interest (ROI). The amount of pixelation change between adjacent video frames quantifies bodily movement in the video frame when there are no other moving objects in the predefined ROI. Because MEA provides an objective measurement of movement dynamics and is relatively unobtrusive, it permits calculation of a latent, nonconscious movement dynamics, and participants are therefore less susceptible to response bias and demand characteristics. The ROIs in this study were the entire body of each partner and configurations were set to best capture the movement of the romantic partners (See Figure 1).

Figure 1 below depicts the total number of frames processed for this video was 78,870 at 29.97003 frames per second. The first region of interest (ROI) is the female partner's full body. The second region of interest is the male partner's full body. The black box in the right upper-corner depicts the change in motion from frame-to-frame. At this particular moment, the change

in pixilation reflecting the female partner's movement (ROI 1) was 12,865, whereas her partner's slight head and arm movement (ROI 2) resulted in a change in video pixilation of 2,412. Movement data is obtained by following steps 1-8. The 78,870 lines of movement data are exported in two columns (ROI 1 and ROI 2) in a text-file that is subsequently imported to R-studio and cross-lagged correlations were analyzed using the "rMEA" tools package, and the smoothing function in R was used to minimize the influence of drastic changes in lighting.

        Cross-lagged correlation. The movement data of each partner was extracted via MEA. Interactional synchrony was calculated for the entire duration of the videos. I used a 30-second window that moves across the whole interaction second-by-second. This allows for variation across the whole interaction and helps with problems of non-stationarity. A cross-correlation was then applied between the two time-series (i.e., each ROI) using a 5-second time-lagged window of interaction. This method follows that proposed by Ramseyer and Tschacher (2011). It has demonstrated the ability to accurately capture the nonverbal synchrony between romantic partners (Delaherch et al., 2012). Figure 2 depicts cross-lagged correlations for an example dyad from the current dataset.

        This figure shows that the male partner led the movement at a slightly higher rate and a substantial amount of interactional synchrony was present from about minute 2 to 5, from minute 23 to 26, and from about minute 54 to 55. Notably, using these types of heatmaps provide a nice visual of the overall pattern of synchrony at the dyadic level but there may be practical uses for such graphics. For example, one could effectively multiply the ccf window by the number of seconds, then multiply the resulting value by the number of frames per second (29.97003), and then subtract the result from 1 in order to locate a specific event in the video. The time-series for

each dyad are then converted to an overall standard score based on Fisher's Z to provide an estimate of average interactional synchrony during the interaction.

Measures of Relationship Quality

Intimacy Safety Questionnaire-Short Form (ISQ-SF). The ISQ-SF is a 10-item scale that was designed to measure Couples' intimate Safety (Cordova, Blair, & Meade, 2010). It is a shortened version of the larger 14-item scale; thus, the reliability information provided here pertains to the 14-item scale. It is significantly correlated with the Personal Assessment of Intimacy in Relationships Questionnaire (rs = -.78 and -.73 for men and women, respectively) and the Emotional Intimacy Subscale (rs = -.82 and -.80 for men and women, respectively). Items include the following: "I feel comfortable telling my partner things I would not tell anyone else," "When I am with my partner I feel more safe and comfortable than I do with most others," and "When things aren't going well for me, it's comforting to talk to my partner." Participants rate each item on a 5-point scale from 0 (*never*) to 4 (*always*). Factor analyses support a single-factor interpretation of the ISQ, and it is interpreted as a measure of emotional intimacy. Overall internal reliability for the current study was acceptable (baseline α = .88, 1-month α = .87).

Communication Patters Questionnaire-Short Form (CPQ-SF). The CPQ-SF is an 11-item self-report questionnaire used to measure each partner's perceptions of their relationship interactions (CPQ-SF; Christensen & Heavey, 1990, 1993; Heavey, Layne, & Christensen, 1993). All items are rated on a 9-point Likert scale (1= very unlikely; 9 = very likely) and indicate how the couple handles conflict and how they communicate in their relationship. The CPQ-SF has demonstrated acceptable internal consistency for the demand-withdraw subscale (alphas in the .50 to .85 range) and the positive interaction subscale (alphas in the .68 to .91 range). In this study, the CPQ-SF was used to provide an overall positive communication score

by reverse scoring necessary items and then summing all of the items. The reliability for the current study was in acceptable (baseline $\alpha = .84$, 1-month $\alpha = .87$).

Couple Relationship Satisfaction (CSI-16). The CSI-16 is a global indicator of satisfaction in cohabitating and married couples (CSI-16 items; Funk & Rogge, 2007). It contains 16 items that assess global relationship satisfaction. Fifteen of the items are on a 5-point Likert-scale and one item is on a Likert-scale that ranges from 0-6. Higher scores up to 81 indicated higher levels of satisfaction. A sample item reads, "Please indicate the degree of happiness, all things considered, of your relationship." (0 = extremely unhappy to 6 = perfect). In published studies, the internal reliability of the CSI-16 has been acceptable or better, with Cronbach's alpha in Funk & Rogge's (2007) validation study demonstrating excellent consistency ($\alpha = .98$). For the current study, reliability was in the excellent range for all three timepoints (baseline $\alpha = .97$, 1-month $\alpha = .97$, 6-months $\alpha = .94$).

Analytic Strategy

To examine Hypothesis 1, a two-level multilevel model (random intercepts linear-mixed effects model) was used to examine the effects of interactional synchrony on relationship satisfaction, emotional intimacy, and constructive communication at each time point (baseline, 1-month, 6-months [for satisfaction only]). Following Hox's (2010) recommendations, in the first step, the intercepts only model (null) was calculated to determine whether the intraclass correlation coefficient (ICC) showed enough variation between dyads to justify the use of multilevel modeling. For each step thereafter, a random intercepts model with additional parameters was examined with respect to model fit. Per the recommendations of Hox (2010), in the second step, the Level-1 variables were entered into the model, which included the covariates gender and mental health concerns. In Step 3, interactional synchrony, as the main fixed effect

of interest was added to the model. In Step 4, the Level-2 covariates identified in preliminary analyses (poverty status and parenting status) were entered into the model. At each subsequent step, as additional parameters were added to the model, improvement in model fit was assessed using the chi-square deviance test of -2 Loglikelihood.

To examine Hypothesis 2, whether or not there are differences in the level of synchrony manifested for different types of conversations, a one-way ANOVA with planned contrasts (courtship story, strengths discussion, concerns discussion) was employed to determine whether interactional synchrony scores differed based on conversation type.

To examine Hypothesis 3a, whether interactional synchrony predicts changes in relationship quality variables (relationship satisfaction, emotional intimacy, and positive communication), average interactional synchrony scores during the assessment portion of the intervention were regressed on the relationship quality variables at 1-month and 6-months (for satisfaction), while controlling for baseline levels of relationship satisfaction, emotional intimacy, and constructive communication, respectively. In addition, the covariates that explained substantial variance in Hypothesis 1 were controlled for in the 2-level random intercepts models.

Results

Preliminary analyses

The distributional characteristics for the continuous interactional synchrony predictor variables and the relationship quality outcome variables are shown in Table 2. Means and standard deviations for relationship satisfaction were very similar those in the original study ($N = 864$) at baseline ($M = 58.59$, $SD = 18.14$), one-month ($M = 64.07$, $SD = 16.04$), and 6-months ($M = 66.26$, $SD = 20.06$) post-intervention ($ps > .05$). The normative data ($N = 5,315$) from which the CSI-16 was validated (Funk & Rogge, 2007) reports a rounded mean of 61.00 and a standard

deviation of 17.00, which is on par with the current sample. Similarly, means and standard deviations for constructive communication in the original study ($N = 907$) were not significantly different at baseline ($M = 54.91$, $SD = 17.08$) or 1-month post-intervention ($M = 61.68$, $SD = 16.31$). Likewise, for emotional intimacy in the full sample (847) the means and standard deviations at baseline (30.46, $SD = 7.23$) and 1-month post-intervention (34.489, $SD = 6.33$) were very similar ($ps > .05$). This suggests that the current sample is relatively representative.

Checks for normal distribution of residuals, outliers, and multicollinearity were also conducted. Predictor variables were fairly normally distributed. The scatterplots in Figure 3 show the distributional characteristics of the residuals for each of the outcome variables predicted by baseline interactional synchrony. Fairly normal distribution takes the form of a rectangle with residuals generally evenly distributed around the zero points. Tabachnick and Fidell (2007) define outliers as those standardized residuals of more than 3.3 or those less than -3.3.

In considering all three distributions of residuals on the outcome variables, for relationship satisfaction, there appears to be one participant whose residual variance lies outside the normal range. For emotional intimacy, there are two individuals whose residual values lie outside the normal range. Additionally, both relationship satisfaction and emotional intimacy were slightly negatively skewed which could pose problems, particularly with smaller samples. Multilevel modeling, particularly with robust full estimation maximum likelihood, helps deal with violations of statistical assumptions by grand mean centering quantitative predictor variables (Hox, 2010). The standardized residuals for constructive communication predicted from baseline interactional synchrony residuals were fairly normally distributed, with no apparent outliers. Given this was a suffficiently large sample and a simple check for robustness

of residuals indicated that correlations were not substantially attenuated when outliers were excluded, outliers were included in subsequent analyses.

Pearson correlations with listwise deletion of all study variables are shown in Table 3. With the exception of the association between interactional synchrony during the conversation about the courtship story and constructive communication ($r = .07$, $n = 152$, $p = .413$), and the association between interactional synchrony during the discussion of relationship strengths and emotional intimacy measured at 1-month ($r = .15$, $n = 147$, $p = .07$), all other variables were significantly correlated. there were no correlations above .60 for synchrony during the different types of conversational contexts, posing no issues with multicollinearity (Tabachnick & Fidell, 2007). Thus, the variables were highly related but sufficiently independent to be examined as separate predictor variables. Overall, interactional synchrony was generally associated with all relationship quality outcome variables at all time-points, and interactional synchrony during the full video was reliably correlated with synchrony during the discussion of the courtship story ($r = .74$, $p < .01$), strengths ($r = .72$, $p < .01$) was highly correlated with each of the three sections ($> .70$), it can be assumed that the full video provides an adequately stable approximation of interactional synchrony for multilevel analyses.

As a second assumption check, robust parameter estimation requires that data be missing at random. Several covariates were examined for their associations with missingness at each stage of the intervention. Chi-square analyses showed that among couples who consented to have their video data used for subsequent analyses and who met criteria for inclusion in this study, poverty status (6-months), parenting status(1-month), and endorsement of mental health concerns (1-month) were associated with missing data (See Table 4). Specifically, 40% of couples in which at least one partner reported having children did not complete their 1-month

follow-up assessment packets, and 24% of those couples who endorsed significant mental health concerns did not complete their 1-month packets. For the 6-month wave of data collection, 13% of participants who reported having an income below the poverty line did not complete their 6-month assessment packet. Thus, for the linear mixed-effects multilevel models that were used to examined the hypothesis 1 and hypothesis 2 of this study, mental health concerns was included as Level-1 (between subjects) covariate and parenting status included as a Level-2 (within subjects) covariate in the Stepwise model building process.

Additionally, most research investigating the effects of interactional synchrony typically uses same-sex dyads because there is evidence that synchrony is stronger in same-sex dyads compared to different sex dyads (e.g., Grammer, Kruck, & Magnusson, 1998), with a recent study showing that female dyads exhibited higher levels of interpersonal synchrony than males (Fujiwara, Kimura, & Daibo, 2019). Therefore, since this study included both same-sex and heterosexual romantic couples, gender was also included as a Level-1 covariate.

Hypothesis 1: *Interactional synchrony in romantic dyads will be positively associated with indicators of romantic relationship outcomes (constructive communication, emotional intimacy, relationship satisfaction) at all waves of data collection (baseline, 1-month, and 6-months [satisfaction only]) post-intervention.*

Multilevel analyses require that substantial portion of the between person variance be due to group membership. As a preliminary step, Intraclass Correlation Coefficients (ICC) were calculated for each of the dependent variables in this study (see Table 5).

The ICC indicates the proportion of total variance in scores that is due to between-partner differences in each dyad relative to the proportion of the within-person variance. For example, the ICC for Relationship Satisfaction (CSI-16) was .63, meaning that approximately 63% of the

total variance in relationship satisfaction was due to between-partner differences and approximately 27% of the variance was due to within person variance at baseline. The fact that there was substantial variance due to between partner differences for all time-points suggests there is good reason to cluster individuals within couples to account for the nonindependence of the data. As shown in Table 5, the models fitted at baseline and 1-month reflected similar dependency in data for constructive communication and relationship satisfaction, and slightly more within person variance for scores on emotional intimacy. There were no waves of data collection at 6-months for emotional intimacy or constructive communication. Overall, the ICCs show substantial variation in the outcome variables of interest. The model for which baseline ICCs were calculated is referred to as the intercepts only, baseline or null model. For the clarity purposes and to save space, the null model (Step 1) is not depicted in the linear mixed effects models pictured in Tables 6-12.

Hox (2010) recommends comparing nested models to the more parsimonious model in the previous step by calculating a deviance statistic. This is generally done by multiplying the Log-likelihood statistic by -2 for each successive model, while taking into consideration the difference in the additional parameters being estimated in the model. Following Hox's (2010) recommendations, in Step 2 gender (0 = male, 1 = female) and mental health concerns (0 = no concerns, 1 = concerns) were included as Level-1 covariates in the random intercepts model. The chi-square deviance for the overall model fit was compared to the previous model where fewer parameters were estimated. In Step 3, the main test of my hypothesis, interactional synchrony was entered into the model on Level-2. All models included the main predictor variables as fixed effects with random intercepts (individuals nested within dyads). In Step 4, poverty status (0 = above poverty threshold, 1 = below poverty threshold) and Parenting Status

(0 = no children, 1 = one or more children in the home) were entered as Level-2 control variables. For the purposes of clarity and to save space, the null model (Step 1) is not depicted in Tables 6-12. Step 2 was a significant improvement over the null model for all models pictured. Hereafter, I refer to Step 2 as *Model 2*, Step 3 as *Model 3*, and Step 4 as *Model 4*, respectively.

The full models are pictured in Tables 6-12 but only the fixed effects for the crucial hypothesis of interactional synchrony on the dependent variables are interpreted. Because interactional synchrony was grand mean-centered, and all other variables were categorical, standardized betas are used for interpretation. Importantly, as there was no random assignment to conditions nor experimental control, temporal precedence was not addressed. Interactional synchrony is discussed as a predictor only in the sense of its predictive variance as a fixed effect in the regression models.

Interactional Synchrony and Relationship Satisfaction at Baseline

Below, for illustrative purposes, I describe in detail the model building process recommended by Hox (2010) with the current data depicted in Table 6. In describing the results for the fixed effects of the interactional synchrony on the other outcome variables, hereafter I only note the best fit model using the process described below and interpret the fixed effects for the critical hypothesis of interactional synchrony on each the relationship quality variables. However, the full models are reported in Tables 6-12.

Table 6 shows that Model 3 was the best fit model from which to interpret the fixed effect of interactional synchrony on relationship satisfaction at baseline. Model 2 had a log-likelihood of -867.473. Multiplying this value by -2 with an additional 2 parameters, the resultant deviance statistic was 1734.946, which was a significant improvement over the null model X^2 (2, 213) = 36.45, $p < .001$). In the critical test of my hypothesis, Model 3 showed

significant improvement over Model 2, which only included gender and mental health concerns as fixed effects, X^2 (1, 213) = 12.58, $p < .001$). Accounting for the effects of poverty status and parenting status was in Model 4 did not improve the model fit X^2 (2, 213) = 2.40, $p < .30$), nor did Model 4 account for more variance than the previous model (see the R^2 approach; Edwards, Muller, Wolfinger, Qaqish, & Schabenberger, 2008). With the addition of poverty status and parenting status, the random effects variance statistic ($\sigma2$) went from 103.31 to 103.75, which also indicates poorer model fit. The Marginal R^2 statistic (.146) reflects the variance explained by mental health concerns, gender, and the interactional synchrony as fixed effects reflects.

When modeling the random effects, a substantial proportion of the variance was explained by mental health concerns, gender, and interactional synchrony (Conditional R^2 = .604). Model 3 was the best fitting model. While controlling for gender and mental health concerns, interactional synchrony significantly predicted couple relationship satisfaction at baseline, $\beta = .28$, SE = .07, $t = 3.64$, $p < .001$. Thus, those who exhibited higher levels of interactional synchrony endorsed higher levels of satisfaction and the effect was strong ($d = .69$). In addition, while controlling for the other variables in the model, results showed that both gender ($\beta = -.12$, SE = .04, $t = -2.68$, $p = .007$) and mental health concerns ($\beta = -.22$, SE = .06, $t = -3.15$, $p = .002$) predicted couple relationship satisfaction. Although gender and mental health concerns were merely included as control variables due to patterns of missingness, and no predictions were made in regard to their explanatory variance, it is worth noting that, even while controlling for interactional synchrony and mental health concerns, female participants were more likely to endorse lower levels of relationship satisfaction at baseline. Notably, females were also more likely to be the ones who signed up for the intervention, which may suggest they were indeed less satisfied with their relationships on average. Similarly, while controlling for

gender and interactional synchrony, those who endorsed mental health concerns were more likely to endorse lower relationship satisfaction.

Interactional Synchrony and Relationship Satisfaction at 1-month Post-intervention

See Table 7 for a full report of these results. There was a significant improvement in model fit from the null model to Model 2, where gender and mental health concerns were entered as Level-1 predictors. However, in contrast to the baseline model, in Model 2, gender did not significantly predict couple relationship satisfaction (β = -.02, SE = .04, t = -0.44, p = .662). Most notably, in the critical test of my hypothesis, results showed that in the third step Model 3 was a significant improvement over Model 2, X^2 (1, 213) = 7.21, p = .007; however, Model 4 did not show significant improvement compared to Model, X^2 (2, 213) = 2.21, p = .327. Therefore, Model 3 was retained as the best fit model from which to make interpretations. While controlling for gender and mental health concerns, interactional synchrony predicted couple relationship satisfaction at 1-month post-intervention, β = .26, SE = .09, t = 2.75, p = .006, with relatively strong effect (d = .63). Mental health concerns also significantly predicted couple relationship satisfaction, β = -.29, SE = .08, t = -3.63, p < .001. Although not part of the critical hypothesis, and thus interpretations should be made cautiously, those who endorsed mental health concerns scored about 9 points lower on couple relationship satisfaction on average than those who did not endorse mental health concerns at 1-month post-intervention.

Interactional Synchrony and Relationship Satisfaction at 6-month Post-intervention

See Table 8 for a full report of these results. Model 2 was a significant improvement over the null model. In the critical test of my hypothesis, results again showed that in the third step Model 3 was a significant improvement over Model 2, X^2 (1, 213) = 7.72, p = .005, and Model 4, did not show significant improvement compared to Model 3, X^2 (2, 213) = 3.31, p = .191. Thus,

Model 3 was retained as the best fitting model from which to make interpretations of the data. While controlling for gender and mental health concerns, interactional synchrony predicted couple relationship satisfaction at 6-month post-intervention, $\beta = .26$, SE $= .09$, $t = 2.76$, $p = .006$, and the fixed effect for interactional synchrony was strong ($d = .76$). Again, although not part of my critical hypothesis, gender again emerged as significant predictor of couple relationship satisfaction ($\beta = -.24$, SE $= .07$, $t = -3.62$, $p < .001$), and mental health concerns also predicted relationship satisfaction, $\beta = -.29$, SE $= .06$, $t = -3.14$, $p < .001$, with those who endorsed mental health concerns scoring about 7.5 points lower than those who did not, and female participants reporting about 6.5 points less on their relationship satisfaction measure at 6-monts post-intervention relative to male participants.

Interactional Synchrony and Emotional Intimacy at Baseline

See Table 9 for a full report of these results. Model 2 was a significant improvement over the null model. In the critical test of my hypothesis, results again showed that in the third step Model 3 was a significant improvement over Model 2, X^2 (1, 213) $= 4.75$, $p = .029$, and Model 4, was not a significant improvement compared to Model 3, X^2 (2, 213) $= 0.566$, $p = .753$. Similar to the previous models, Model 3 was retained as the best fitting model. While controlling for gender and mental health concerns, interactional synchrony predicted emotional intimacy at baseline, $\beta = .16$, SE $= .07$, $t = 2.21$, $p = .027$, and the effect was moderate ($d = .44$). Mental health concerns also predicted emotional intimacy, $\beta = -.30$, SE $= .07$, $t = -4.32$, $p < .001$, with those who endorsed mental health concerns scoring about 4 points lower on emotional intimacy relative to those who did not endorse mental health concerns.

Interactional Synchrony and Emotional Intimacy at 1- month Post-intervention

See Table 10 for a full report of these results. There was a significant improvement in model fit from the null model to Model 2, where gender and mental health concerns were entered as Level-1 predictors. In the critical test of my hypothesis, results showed that in the third step Model 3 was a significant improvement over Model 2, X^2 (1, 213) = 3.83, p = .050. Model 4, which included poverty status and parenting status again failed to show significant improvement compared to Model 3, X^2 (2, 213) = 0.41, p = .812. Thus, Model 3 was retained as the best fitting model from which to make interpretations. While controlling for gender and mental health concerns, interactional synchrony predicted emotional intimacy at 1-month post-intervention, β = .17, SE = .09, t = 1.99, p = .047, with a moderate effect size (d = .46). As with the baseline model, there was also a fixed effect for mental health concerns on emotional intimacy, β = -.35, SE = .08, t = -4.32, p < .001. Participants who endorsed mental health concerns scored about 4 points on emotional intimacy relative to those who did not endorse mental health concerns at 1-month post-intervention.

Interactional Synchrony and Constructive Communication at Baseline

See Table 11 for a full report of these results. Model 2 was a significant improvement over the null model. In the critical test of my hypothesis, results showed that Model 3 was a significant improvement over Model 2, X^2 (1, 213) = 4.29, p = .038, and Model 4, was not a significant improvement compared to Model 3, X^2 (2, 213) = 1.03, p = .596. Model 3 was retained as the best fitting model. While controlling for gender and mental health concerns, interactional synchrony predicted emotional intimacy at baseline, β = .17, SE = .08, t = 2.09, p = .037, and the effect was moderate (d = .40). Mental health concerns also predicted emotional intimacy, β = -.23, SE = .07, t = -3.58, p < .001, with those who endorsed mental health concerns

scoring about 8 points lower on constructive communication relative to those who did not endorse mental health concerns.

Interactional Synchrony and Constructive Communication at 1- month Post-intervention

See Table 12 for a full report of these results. There was a significant improvement in model fit from the null model to Model 2, where gender and mental health concerns were entered as Level-1 predictors. In contrast to all previous models, however, Model 3 was not a significant improvement over Model 2, X^2 (1, 213) = 1.82, p = .177. Interactional synchrony did not add substantial variance to the model, but there was a modest increase in the variance explained by the fixed effects in Model 3, as Marginal R^2 increased from .108 to .129, and the variance statistic ($\sigma 2$) showed a slight reduction; however, the ICC remained at .60. Model 2 indicated a fixed effect for mental health concerns on constructive communication, β = -.32, SE = .07, t = -4.13, p < .001. The prediction that interactional synchrony would predict variance in constructive communication at 1-month post-intervention was not supported.

Hypothesis 2: The level of interactional synchrony present will differ by conversation type (courtship story, strengths, and concerns), with less synchrony manifested in the discussion of relationship concerns than the discussion of the courtship story and strengths.

I hypothesized that more interactional synchrony would be present in affiliative versus conflictual conversations with pairwise comparisons. As a preliminary step, I visually examined whether there was sufficient variance in interactional synchrony over the course of the intervention by breaking interactional synchrony into quartiles by conversation type. A visual inspection of the means suggests that there was significant variation within each section (see Figure 4).

For the main test of the hypothesis, a one-way repeated measures ANOVA was conducted to compare scores in interactional synchrony by conversation type. A repeated measures design was used as opposed to a between-groups design because the couples participated in all three conditions (conversation types) and these conveniently progressed in linear order. Each couple engaged in a conversation about their courtship story (Time 1), then discussed their relationship strengths (Time 2), followed by a discussion of their relationship concerns (Time 3). Means and standard deviations are presented in Figure 5.

Results demonstrated that there was not a significant main effect for conversation type, Wilks Lambda = .97, F (2, 116) = 1.81, p = .16, partial eta squared = .03, which indicates that mean synchrony scores did not significantly differ based on conversational context. Thus, this hypothesis was not supported.

Hypothesis 3: Interactional synchrony over the assessment portion of the relationship intervention will predict increases in intimacy, positive communication, and relationship satisfaction, while controlling for baseline levels of relationship satisfaction, emotional intimacy, and constructive communication.

As illustrated in Table 13, while controlling for baseline levels of the relationship quality variables, as well as mental health concerns and gender, average interactional synchrony did not predict change in any of the relationship quality variables from baseline to the subsequent timepoint.

For relationship satisfaction, while controlling for mental health concerns and gender, as well as baseline relationship satisfaction, interactional synchrony did not predict change in relationship satisfaction from baseline to 1-month (β = .07, p = .330) or baseline to 6-months (β = .17, p = .057) post intervention. However, it is worth noting that interactional synchrony

predicting relationship satisfaction at 6-months approached significance. Additionally, female partners were less likely to endorse positive change in relationship satisfaction relative to males (β = -.15, p = .013).

For emotional intimacy, while controlling for mental health concerns and gender, as well as baseline levels of emotional intimacy, interactional synchrony did not predict change in emotional intimacy from baseline to 1-month (β = .01, p = .829).

Similarly, for constructive communication, while controlling for mental health concerns and gender, as well as baseline levels of constructive communication, interactional synchrony did not predict changes in constructive communication from baseline to 1-month (β = .07, p =.344). However, those who endorsed mental health concerns were more likely to report a decrease in constructive communication (β = -.19, p = .005) relative to those who did not endorse mental health concerns.

Discussion

The primary aim of this study was to investigate the role of interactional synchrony in committed romantic couples. The vast majority of studies examining the effects of synchronous movement aim for experimental control. Studies that speak to the ecological validity of interactional synchrony rather than the causal effects of behavioral synchrony are relatively scant. To fill this gap in the literature, I examined interactional synchrony in the context of committed romantic couples during a brief relationship intervention (Gordon et al., 2019). To my knowledge, this the first study that used automated frame-differencing methods to examine interactional synchrony in committed romantic couples.

To test the first hypothesis, the relationships between nonverbal synchrony and well-established indicators of relationship quality in romantic couples were examined. Results

demonstrated that interactional synchrony was generally associated with relationship satisfaction, constructive communication, and emotional intimacy. The associations between interactional synchrony these self-report outcome variables were assessed at baseline and 1-month post-intervention and relationship satisfaction was additionally assessed at 6-months post-intervention. Of these seven measurement occasions, the only nonsignificant fixed effect was the association between interactional synchrony and constructive communication at 1-month post-intervention. The magnitude of these effects was in the medium to large range (d = .40 to d = 76). The effects were fairly stable, even while controlling for parenting status, poverty status, gender, and mental health concerns. Results support previous research that has linked interactional synchrony during individual therapy sessions with therapeutic alliance, positive affect, and rapport (Galbusera et al., 2016; Hove & Risen, 2009; Ramseyer & Tschacher, 2011; Tschacher et al., 2014). Previous studies have been tightly controlled studies, and whether these methods could be extrapolated to committed romantic couples in settings with less experimental control was unclear. Despite methodological limitations, when averaged across the entire video interactional synchrony was relatively reliable index of synchronous movement. Moreover, it is worth noting that the effects of interactional synchrony held across 6 of the 7 assessments on the outcome variables, suggesting that interactional synchrony may be a reliable predictor of relationship quality.

The associations between nonverbal synchrony and common indicators of relationship quality in romantic couples found in this study suggest that interactional synchrony may serve as an objective and non-intrusive indicator of relationship quality. Interactional synchrony as it is measured in the present study is a nonconscious pattern of behavioral coordination. Its measurement is unknown to the interactants; thus, it can be considered an objective behavioral

measure that is not subject to the same limitations as self-report measures, such as socially desirable responding. As has been shown in a wide range of experimental research with unacquainted dyads, interactional synchrony reflects a sense of social attunement, empathy, or social connectedness, all of which are difficult to measure but are nonetheless essential in couple romantic relationships. Moreover, in addition to self-report measures of couple relationship quality, elaborate behavioral coding systems have been developed to study romantic couple interactions. The automated objective methods used in the current study hold several advantages in this regard.

Given how the video recordings took place in naturalistic settings, under real conditions, with romantic couples discussing real relationship issues, a major implication of this study is that MEA may be a suitable assessment tool in more practical contexts. Motion energy analysis (MEA) efficiently quantifies movement dynamics. The "rMEA" package provides a set of analytic tools that may have practical use for clinicians and researchers. Coordinated movement between partners is only one of many indicators that may be used for multimethod assessment of relationship quality, but as frame differencing methods advance, combining verbal and nonverbal components of movement coordination may provide more specific data about the dynamics of romantic couple relationship quality. Notably, this measure is more of a blunt measure of overall nonverbal synchrony. It is does not differentiate between different aspects of synchrony (e.g., mimicry versus responsiveness) or delineate the special dynamics of the interpersonal interaction (e.g., moving in versus moving away). Yet, this study provided preliminary evidence that synchronous nonverbal movement may be a reliable predictor of couple relationship quality despite this limitation.

Hypothesis 2 was not supported. The presence of interactional synchrony was not stronger in affiliative conversations (discussion of courtship story and relationship strengths) than contentious conversations (relationship concerns), which suggests that couples who have a tendency to coordinate their movement during interpersonal interactions may be able to maintain synchrony even during difficult conversations. That is, in committed romantic couples, synchronous interactions may be less dependent on the affective quality of the interaction. Although several studies have demonstrated that the effects of synchrony vary by conversational context (Bernieri et al., 1996; Paxton & Dale, 2013) with more synchrony generally found in more affiliative than conflictual conversations, these data did not corroborate previous findings. As the aforementioned studies examined contextual effects using unacquainted dyads, it was unclear how interactional synchrony would unfold in committed romantic couples discussing real concerns (and strengths) in their relationships. Results of this study suggest that the presence of interactional synchrony is not different based on conversational context, as least when measured in romantic couples.

The most likely explanation for which I did not finding support for this hypothesis is that committed romantic couples likely have different motivations than unacquainted dyads. For instance, romantic partners may simply have more at stake when they do not socially engage with one another. It may be advantageous for romantic couples to socially attune to and respond empathically to their partner in ways that may not be as crucial for unacquainted dyads. Indeed, a large body of research has shown that not engaging (i.e. withdrawing from one's partner) is a destructive pattern of interaction that can lead relationship distress (Christensen, Jacobson, & Doss, 2014; Gottman, 2005). Romantic couples likely have additional reasons to maintain behavioral synchrony during conflicts that benefit their relationship and do not necessarily apply

to unacquainted dyads. Although research is only beginning to examine the possibility that there may be potentially negative implications resulting from too much interactional synchrony (Coutino et al., 2019), as well as the notion that self-regulation may be impaired by excessive levels of interactional synchrony (Galbusera et al., 2019), these more nuanced investigations are relatively scant in the current literature. There are likely some contexts in which synchrony may not be quite as beneficial, or even disadvantageous. Further empirical research should examine different conversational contexts and interactional synchrony with independent samples of committed romantic couples, particularly with counterbalanced conditions that allow one to examine whether some synchrony in some contexts versus others are more advantageous.

Nevertheless, when conceptualized in terms of social attunement, engagement, and responsiveness, the finding that interactional synchrony in romantic couples does not vary based on conversation context may be interpreted as an indication that being engaged with one's partner even in difficult conversations is profoundly important for the relational health of romantic couples. In a sense, this finding supports previous research on approach/avoidance behaviors (demand/withdraw) in romantic couples, which has shown that this pattern reflects a lack of engagement and responsiveness in romantic relationships and is generally destructive (Christensen, Doss, & Jacobson, 2014, Gottman, 1994). A productive avenue for future research will be to examine the convergence or divergence of different measures of engagement and responsiveness in different contexts. Research investigating extent to which these measures dovetail in different contexts with different populations should move the field of communication patterns in romantic couples forward. For example, one line of research might investigate whether elderly couples versus younger couples are more likely to be synchronous in certain contexts, or further investigate whether being in synchronous during an intense argument with

one's partner has different implications than being synchronous during a pleasant conversation. This study raises important questions about when interactional synchrony may be important for relationship health and when it may be less critical.

Finally, I hypothesized that levels of interactional synchrony may predict changes in relationship quality variables after the intervention. I reasoned that interactional synchrony might be a prerequisite for emotional engagement, attachment, and empathic responding, and therefore couples with higher levels of interactional synchrony might be more socially attuned and therefore amenable to positive changes in the quality of their relationship. However, results did not support this hypothesis. Interventions that focus specifically on bodily movement and increasing nonverbal behavioral synchrony may be necessary to bring about changes as a consequence of synchronous movement. Body-movement psychotherapy and dance movement psychotherapy for couples are examples of contemporary interventions that specifically target movement synchrony. In sum, despite not finding support for hypothesis 2 or hypothesis 3, the effects of behavioral synchrony on relationship satisfaction, emotional intimacy and constructive communication were relatively stable.

The notion that our subjective perceptions are tied to the movements of others is not a new idea. In his philosophical anthropology, Martin Buber (1965) wrote "Our behavior rests upon innumerable unifications of movements to something. There is no movement that is not directly or indirectly connected with a perception, and no perception that is not more or less consciously connected with a movement" (p. 156). Overall, results suggest that interactional synchrony is linked with indicators of relationship quality in romantic couples, it does not vary based on conversational content, and it does not predict changes in satisfaction, emotional intimacy, and constructive communication following a brief short-term intervention. The fact

that interactional synchrony was significantly related to these relationship outcome variables at each time-point, suggests that it may emerge early in development and, at least in the context of romantic couples, may operate similar to how attachment style has been conceptualized in the romantic couple literature. Attachment style develops early in the context of interpersonal relationships and is relatively stable (Bowlby, 1977; Johnson, 2004) but may be altered to some extent based on the ability of one's romantic partner to communicate a sense of trust and emotional safety (Johnson, 2015). Similarly, this study provides preliminary evidence that interactional synchrony may be a relatively stable indicator of romantic couple relationship quality that may be difficult to change without targeted interventions.

Research on interactional synchrony may illuminate the import of both individual-level dynamics (i.e., intra-personal) and couple-level dynamics (inter-personal) because it permits investigation of the patterns that unfold in a contingent yet dynamic process between persons. However, it is important to note that there may be differences in the amount of closeness or intimacy one or both partners desire at the individual level. There may be some individuals with specific personality traits (see e.g., schizoid personality disorder), autism spectrum disorders, or other individuals who exhibit traits that would likely be more satisfied not engaging in close relationships. In fact, personality disorder is increasingly conceptualized dimensionally (Bender, Morey, & Skodol, 2011; Hopwood et al., 2018), which means that even individuals who function in the normative range are likely to differ with regard to their capacity for empathy and intimate relationships. Thus, individual differences may have substantial implications for the level of interactional synchrony one is able to engage in. The current study investigated interactional synchrony from a dynamic systems perspective without much consideration for individual

differences, but it may be helpful to investigate the role of individual differences in future studies.

Limitations

Several limitations must be acknowledged in the context of the present results. First, this study lacked a great deal of experimental control relative to other studies that have used frame-differencing methods, which is a critical limitation that must be considered and discussed in some detail. The methodology outlined by Ramseyer and Tschacher (2011) was followed as closely as possible. However, the sample was a convenience sample, and the videos used for MEA analyses in this study were recorded in diverse settings, typically delivered in the homes of particular couples or different community clinics. It is certainly possible that delivering the intervention in the comfort of one's home may result in relatively higher synchrony scores than when delivering the intervention in a standard clinical setting, which may have confounded the results. Nesting couples within clinic settings or therapists in third and fourth level multilevel analyses, may have improved the precision with which the effects of interactional synchrony could be estimated.

Although interactional synchrony did not differ by conversational type in hypothesis 2, examining this hypothesis with observational data in a within-subjects design is an important limitation. A between-subjects design is more appropriate for investigating contextual effects, as carryover effects going from one context to the next can influence results. It is possible that differences might emerge in study that included counterbalanced conditions and manipulation checks with the specific aim of examining contextual effects of interactional synchrony. For instance, couples may have become more synchronous from the discussion of their courtship story to the discussion of their relationship strengths and then experienced an abrupt change in

affect as they began to discuss their relationship concerns. The possibility that this abrupt change in conditions may have accounted for the null finding is only speculative but cannot be ruled out. A within-subjects design that is observational by nature, such as this study, is always subject to potential carryover effects.

Furthermore, inclusion criteria for using MEA requires that several methodological conditions be met (Ramseyer, 2020; Ramseyer & Tschacher, 2011). For example, a constant light source is one of many prerequisites for frame-differencing with MEA. Within each video, the light source was constant; however, between videos, the lighting conditions varied substantially, which may have affected the results. With regard to changes in lighting, I did not empirically investigate the extent to which unstable lighting conditions may have influenced movement calculations. Thus, the methodological requirements of constant lighting conditions MEA analyses were not fully met. Additionally, some of the videos used for analyses had external objects (e.g., pets or small children) within the video frame for up to 10 percent of the video. These are serious limitations concerning experimental control that must be considered in interpretation of the results. To have a sufficient sample size, the decision was made to include the 10 percent caveat. Over the entire duration of the videos, many of the potential confounds were likely neutralized. However, artificial movement may have been introduced as a result of the MEA methodological conditions not being fully satisfied.

Moreover, the generalizability of these findings may be seriously limited in the sense that couples who were sitting close together or displaying physical affection for more than 10 percent of the video were excluded from analyses. Physical displays of affection have been linked with relationship satisfaction (Gulledge, Gulledge, & Stahmannn, 2003), emotional security (Jakubiak & Feeney, 2016a), and other relationship outcome variables (for a review, see Jakubiak &

Feeney, 2016b). Thus, due to the stringent inclusion criteria for frame-differencing with MEA, a number of couples that presumably had high levels of emotional intimacy and relationship satisfaction may not have been included in these analyses. Consequently, interactionally synchrony was not assessed for couples who sit close together, tend to hold hands, or put their arms around one another, for example, which poses a serious methodological limitation. The possibility that couples sitting close to one another or who were physically affection may endorse higher levels of relationship satisfaction or emotional intimacy than behaviorally synchronous couples is a strong possibility that could not be addressed in the present study.

Another limitation of this study is that three persons likely contributed to the nonverbal synchrony scores, the facilitator of the conversation, Partner A, and Partner B. However, even though the facilitator contributed to the movement dynamics of the couple, their contribution to the nonverbal synchronous movement within each dyad could not be accounted for. This is a critical limitation because the automated frame-differencing methods only capture change in pixilation, but the average synchrony score likely captured some movement patterns influenced by the facilitator rather than the reciprocation of nonverbal behaviors between the romantic partners. To make the claim that nonrandom and patterned movements between partners characterize nonverbal synchrony, it is important to account for all potential contributions to the movements. Indeed, having a third-party present is a major limitation in this regard. Perhaps, for this reason, researchers have generally shied away from investigating interactional synchrony in romantic couples using frame differencing methods. This study highlights this limitation.

Another limitation of this study is that the videos used were a convenience sample. In the seminal study from which these methods were emulated (Ramseyer & Tschacher, 2011), the authors used a random sample of therapist-patient videos drawn from a larger sample at a

university-based clinic. Although their sample was a convenience sample, they were able to sample from the video archive randomly. Drawing a random sample from a larger corpus of quality videos was not an option for this study. Thus, the generalizability of these findings is further limited. Furthermore, although interactional synchrony was conceptualized as the coordination and reciprocation of simple motor movements over time, the affective, verbal, and linguistic components of the interactions likely influenced the nonverbal synchrony between partners. While MEA is automated technological tool with many advantages, in observational studies using this technology, one cannot rule out as explanatory variables or differentiate the reciprocal influences of behavioral mimicry, language matching, emotional contagion, or other forms of synchronous communication.

Research Implications

Several research implications might be considered in light of the current findings. There was evidence that synchronous motor movement or behavioral coordination between romantic partners should be further studied as an indicator of relationship quality. This was only one study with limited experimental control. As such, interactional synchrony in committed romantic couples warrants further study with improved methods. It is important to think about how to balance experimental control with ecological validity. For example, future researchers should think critically about how to capture the movement dynamics between romantic partners using automated frame-differencing methods, while also accounting for the movement of the therapist. Additionally, this study raises questions about the stability of interactional synchrony in the context of committed romantic couples compared to unacquainted dyads. Researchers should examine whether interactional synchrony manifests differently in romantic couples and that that might mean for their relationships.

Another potentially productive avenue for future research might be to investigate the dynamic interplay between the verbal/linguistic and nonverbal components of interactional synchrony. Early research that used frame-differencing methods (Condon & Ogston, 1966,1967) showed that individuals coordinate their nonverbal behavior with their own language and to the language of other people. Thus, it may be worthwhile to investigate the content and structure of language use in relation to interactional synchrony. Some research (Sillars, Shellen, Mcintosh, & Pomegranate, 1997; Williams-Baucom, Atkins, Sevier, Eldridge, & Christiansen, 2010) has shown that using the pronouns "you" and "me" is negatively associated with relationship quality, and satisfied couples tend to use more integrated personal reference pronouns such as "we," "us," and "ours." Additionally, Simmons, Gordon, and Chambless (2005) reported that couples with higher levels of we-talk were more effective at mutual problem-solving. However, other research has shown that "I" talk is positively associated with relationship satisfaction for women but men's use of the personal pronouns "I" and "me" is negatively associated with their female partners' satisfaction (Slatcher, Vazire, & Pennebaker, 2008). Hence, the effects of pronoun use in committed romantic couples appears to be dynamic and highly contextual.

Moreover, research has demonstrated that language style matching, or *how* a person talks in terms of syntax, accent, rate of speech, and vocabulary level (Ireland, 2011) rather than the content of their conversations, is a nonconscious indicator of social engagement between partners. Language style matching is related to lower perceptions of behavioral responsiveness during conflict (Bowen et al., 2017) but also predictive of relationship stability when couples' displayed a high level of language style matching in their instant messages (Ireland et al., 2011; see also Bierstetel et al., 2020, for a review). Considering how early research on interactional synchrony (Condon & Ogston, 1966,1967) implicated both verbal and nonverbal components of

a dynamic interaction, it is surprising that verbal and nonverbal modes of communication have generally only been studied separately. Although this study focused solely on nonverbal synchronous movement, future research might investigate the coordination of the verbal and nonverbal components of interactional synchrony together, which will likely improve our understanding of interactional synchrony and social engagement in romantic couples.

In addition, research might investigate the nuanced associations between interactional synchrony and constructs such as gender, personality style, and lead-lag relationships between interacting partners, and mental health. Synchrony may operate differently when more contextual factors are considered. For example, more recent research (Galbusera et al., 2019) has begun to investigate and find evidence for what the authors referred to as a tradeoff hypothesis, where self-regulation capacities are disrupted when interactional synchrony is present. This is just one example of a study that showed the double-edged sword of interpersonal synchrony; further research should continue exploration of the drawbacks of interactional synchrony. Although most research, including the present study, has focused on the positive aspects of interactional synchrony, there is no sound evidence that affective experiences are necessarily mutually exclusive. As such, studies should examine whether and what types of drawbacks are associated with interactional synchrony.

Given the effects of gender and mental health concerns found in this study, although they were not part of the crucial hypothesis, another potentially productive area of further research may be to explore actor-partner interdependence models (Kenny, Kashy, & Cook, 2006) that investigate the relationship between who is leading the movement during the couple interactions and whether these lead-lag relationships (see Figure 2) differ by gender or the presence of mental health concerns. In addition, I argued that interactional synchrony is best studied from a

dynamic systems perspective. A fascinating possibility that could lead to a more nuanced

understanding of the role of interactional synchrony might be to produce heat maps like the one I

produced in Figure 2 and qualitatively code the portions of the verbal interactions where there

are clearly high levels of nonverbal synchrony. One could then easily correlate the linguistic

content or style with interactional synchrony. Modern advances in technology will likely open

up many avenues for future research to explore these more nuanced relationships.

Clinical Implications

Emotional intimacy was associated with interactional synchrony in actual conversations

between committed romantic couples. This finding extends previous research that has linked

experimentally induced movement synchrony in romantic couples through the medium of dance

with positive indicators of relationship quality, such empathy (Behrends et al., 2012) and

intimacy (Engelhard, 2018; Sharon-David et al., 2019; Shuper-Engelhard & Vulcan, 2018).

Developing interventions that include activities aimed at improving coordinated body movement

may aid in the improvement of romantic couple relationship functioning. There is promising

research surrounding the use of Dance Movement Psychotherapy for couples (DMP-C; Shuper

Engelhard, 2019a, 2019b) and other interventions are being developed based on the idea that

eliciting synchronous movement helps elicit perspective taking (Lacson, 2020). This is

important because one of the main goals of couple therapists is to improve empathic responding

and couple cohesion. Although a focus on changing verbal communication patterns has long

been part of evidence-based couple interventions, more enactive strategies that take advantage of

bodily forms of communication may prove helpful in improving social attunement and empathic

responding in romantic couple relationships. However, to be sure, this was a proof-of-concept

study with low experimental control, and these results clearly warrant replication before drawing

clinical implications.

Conclusions

Interactional synchrony is associated with relationship satisfaction, emotional intimacy,

and constructive communication. These are generally accepted indicators of romantic couple

relationship quality. Thus, the coordination of nonverbal motor movements between interacting

romantic partners may be an underlying latent indicator of romantic couple relationship quality.

Interactional synchrony might be assessed in addition to self-report measurements to further our

understanding of romantic couple relationships. Romantic couples who endorse higher levels of

relationship satisfaction, emotional intimacy, and positive communication appear to maintain

nonverbal synchrony, regardless of whether they are discussing contentious or more affiliative

topics. Lastly, interactional synchrony does not seem to predict which couples report

improvement in the quality of their relationship post-intervention, which raises important

questions about the stability of interactional synchrony as an indicator of relationship quality in

romantic couples. In sum, nonverbal synchronous movement between romantic partners

warrants further investigation as potentially valuable, and relatively stable indicator of romantic

couple relationship quality.

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Appendices

Table 1. Videos Excluded from Motional Energy Analysis

Reasons for Exclusion from Analyses	Frequency	Percentage
ROIs overlap for more than 10% of the video due to partners sitting too close or touching	28	19%
Upper torso of one or more partners out of the video frame for more than 10% of the video	19	13%
Pet in ROI for more than 10% of the video	16	11%
Baby or small children present in the video frame for more than 10% of the video	15	10%
Poor or unstable lighting for more than 10% of the video	12	8%
ROIs overlap for more than 10% of the video due to camera angle	11	7%
Missing discussion of strengths and concerns per intervention protocol	10	7%
Camera angle resulted in substantially larger ROI for one partner relative to the other	8	5%
Camera angle resulted in facilitator being partially in a ROI	7	5%
Video terminates prematurely (insufficient space on memory card)	7	5%
One or more partners stand up or leave the room more than 3 times	6	4%
Artificial movement from tobacco smoke	3	2%
Blurry Pixilation	3	2%
Artificial movement due to sitting on a rocking chair	2	1%
Totals =	147	100%

Note: ROI stands for Region of Interest. Categories reflect the prominent reason for which videos were excluded from Motion Energy Analyses (MEA).

Table 2. Distributional Characteristics of Sample Data

Relationship Variables	n	Minimum	Maximum	Mean	SD	SE
Relationship Satisfaction						
Baseline	215	8.00	81.00	61.27	16.65	1.14
1-month	132	10.00	81.00	65.05	15.16	1.32
6-months	102	14.00	81.00	66.67	13.49	1.34
Emotional Intimacy						
Baseline	193	9.00	40.00	31.67	6.55	0.47
1-month	147	9.00	40.00	33.31	6.11	0.50
Positive Communication						
Baseline	208	19.00	88.00	56.95	16.51	1.14
1-month	152	19.00	88.00	62.62	16.15	1.31
Interactional Synchrony						
Courtship Story	232	0.0690	0.1912	0.1154	0.0220	0.0014
Strengths	232	0.0693	0.1720	0.1195	0.0218	0.0014
Concerns	232	0.0582	0.1681	0.1164	0.0181	0.0012
Full Video	232	0.0749	0.1564	0.1171	0.0166	0.0011

Note: N = 232.

Table 3. Correlation Matrix of Relationship Quality Variables and Interactional Synchrony

		Relationship Quality						**Interactional Synchrony**			
	1	2	3	4	5	6	7	8	9	10	11
1. Relationship Satisfaction (Baseline)		.763**	.657**	.713**	.632**	.654**	.520**	.236**	.225**	.241**	.309**
2. Relationship Satisfaction (1-month)			.707**	.704**	.786**	.598**	.674**	.234**	.235**	.274**	.314**
3. Relationship Satisfaction (6-months)				.523**	.539**	.549**	.598**	.218*	.330**	.320**	.329**
4. Emotional Intimacy (Baseline)					.769**	.597**	.504**	.195**	.166*	.157*	.208**
5. Emotional Intimacy (1-month)						.460**	.557**	.200*	.148	.201*	.220**
6. Positive Communication (Baseline)							.656**	.249**	.148*	.147*	.195**
7. Positive Communication (1-month)								.067	.172*	.162*	.164*
8. Synchrony (Courtship Story)									.424**	.461**	.743**
9. Synchrony (Strengths)										.508**	.717**
10. Synchrony (Concerns)											.864**
11. Synchrony (Full Video)											

Note. $p < .05$* $p < .01$**

Table 4. Chi-Square Test of Missingness of the Data.

Variable	1-month Dropout %	X^2	2-tail sig.	6-month Dropout %	X^2	2-tail sig.
Gender	30.8	0.01	0.937	32.5	0.14	0.708
Poverty Status	21.7	1.88	0.175	13.0	11.26	0.001**
Minority Status	33.3	0.17	0.681	30.8	0.227	0.634
Marital Status	33.5	2.27	0.132	35.4	0.764	0.382
Parenting Status	40.0	10.33	0.001**	36.7	1.03	0.309
Alcohol Use	22.2	1.96	0.161	37.8	0.373	0.541
Mental Health Concerns	23.7	5.15	0.023**	30.5	1.253	0.263

Note: $p < .05*$, $p < .01**$. Degrees of freedom = 1 for all chi-square difference tests.

Table 5. Intraclass Correlation Coefficients for Level-1 Outcome Variables

Dependent Variables	ICC Baseline	ICC 1-month	ICC 6-months
Relationship Satisfaction (CSI-16)	.63	.64	.55
Emotional Intimacy (ISQ-SF)	.30	.36	--
Constructive Communication (CPQ-SF)	.61	.65	--

Note: All ICCs at each time point indicated substantial interdependence.

Table 6. Dependent Variable is Relationship Satisfaction at Baseline

Predictors	Model 2				Model 3				Model 4			
	Est.	β (SE)	t	p	Est.	β (SE)	t	p	Est.	β (SE)	t	p
(Intercept)	66.67 (1.89)		35.34	**<0.001**	66.37 (1.82)		37.30	**<0.001**	67.42 (2.31)		30.09	**<0.001**
Mental Health	-7.10 (2.16)	-.22 (.07)	-3.29	**0.001**	-6.62 (2.10)	-.20 (.06)	-3.15	**0.002**	-6.98 (2.10)	-.21 (.06)	-3.32	**0.001**
Gender	-3.80 (1.46)	-.12 (.04)	-2.61	**0.009**	-3.88 (1.45)	-.12 (.04)	-2.67	**0.007**	-3.89 (1.45)	-.12 (.04)	-2.67	**<0.001**
Synchrony					276.59 (76.09)	.28 (.08)	3.64	**0.004**	248.61 (77.93)	.25 (.08)	3.19	**0.001**
Poverty Status.									2.98 (3.02)	.07 (.07)	0.99	0.323
Parenting Status									-2.97 (2.55)	-.09 (.08)	-1.17	0.244

Random Effects

σ^2	103.78	103.31	103.75
τ_{00}	138.96 CoupleID	119.41 CoupleID	114.84 CoupleID
ICC	0.57	0.54	0.53
N	114 CoupleID	114 CoupleID	114 CoupleID
Marginal R^2 / Cond R^2	0.062 / 0.599	0.146 / 0.604	0.160 / 0.601
log-Likelihood	-867.473	-861.184	-859.983

Note: Model 3 was the best fit model and the one from which interpretations were made.

Table 7. Dependent Variable is Relationship Satisfaction at 1-Month Post-Intervention

Predictors	Model 2				*Model 3*				Model 4			
	Est.	β (SE)	*t*	*p*	*Est.*	β (SE)	*t*	*p*	*Est.*	β (SE)	*t*	*p*
(Intercept)	70.86 (2.29)		30.93	**<0.001**	70.70 (2.22)		31.82	**<0.001**	70.82 (2.58)		27.41	**<0.001**
Mental Health	-9.42 (2.51)	-.31 (.08)	-3.75	**<0.001**	-8.97 (2.45)	-.29 (.08)	-3.63	**<0.001**	-9.38 (2.45)	-.30 (.08)	-3.83	**<0.001**
Gender	-0.72 (1.66)	-.02 (.05)	-0.44	0.662	-0.63 (1.65)	-.02 (.05)	-0.38	0.704	-0.72 (1.66)	-.02 (.05)	-0.43	0.667
Synchrony					239.11 (86.95)	.26 (.09)	2.75	**0.006**	221.43 (86.91)	.24 (.09)	2.55	**0.011**
Poverty Status.									4.16 (3.22)	.12 (.09)	1.29	0.197
Parenting Status									-1.89 (2.81)	-.06 (.08)	-0.67	0.501

Random Effects

σ^2	75.91	76.07	77.05
τ_{00}	115.91 CoupleID	100.99 CoupleID	94.84 CoupleID
ICC	0.60	0.57	0.55
N	77 CoupleID	77 CoupleID	77 CoupleID
Marginal R^2 / Cond R^2	0.101 / 0.644	0.181 / 0.648	0.206 / 0.644
log-Likelihood	-517.920	-514.317	-513.199

Note: Model 3 was the best fit model and the one from which interpretations were made.

Table 8. Dependent Variable is Relationship Satisfaction at 6-months Post-Intervention

Predictors	Model 2				Model 3				Model 4			
	Est.	β (SE)	t	p	Est.	β (SE)	t	p	Est.	β (SE)	t	p
(Intercept)	73.48 (2.05)		35.89	**<0.001**	73.17 (1.96)		37.30	**<0.001**	74.15 (2.46)		30.09	**<0.001**
Mental Health	-8.44 (2.46)	-.31 (.09)	-3.43	**0.001**	-7.50 (2.39)	-.28 (.09)	-3.14	**0.002**	-8.04 (2.35)	-.30 (.09)	-3.42	**0.001**
Gender	-6.27 (1.81)	-.23 (.07)	-3.46	**0.001**	-6.50 (1.80)	-.24 (.07)	-3.62	**<0.001**	-6.34 (1.81)	-.24 (.05)	-3.49	**<0.001**
Synchrony					221.24 (77.29)	.29 (.10)	2.86	**0.004**	193.56 (76.72)	.25 (.10)	2.52	**0.012**
Poverty Status.									3.44 (2.74)	.12 (.09)	1.26	0.209
Parenting Status									-3.60 (2.62)	-.13 (.08)	-1.37	0.170

Random Effects

σ²	70.79	70.51	72.16
τ₀₀	74.29 CoupleID	60.53 CoupleID	52.41 CoupleID
ICC	0.51	0.46	0.42
N	61 CoupleID	61 CoupleID	61 CoupleID
Marginal R² / Cond R²	0.170 / 0.595	0.260 / 0.602	0.297 / 0.593
log-Likelihood	-388.586	-384.727	-383.073

Note: Model 3 was the best fit model and the one from which interpretations were made.

Table 9. Dependent Variable is Emotional Intimacy at Baseline

Predictors	Model 2				Model 3				Model 4			
	Est.	β (SE)	t	p	Est.	β (SE)	t	p	Est.	β (SE)	t	p
(Intercept)	34.02 (0.80)		42.34	**<0.001**	33.86 (0.79)		42.62	**<0.001**	33.84 (0.97)		34.86	**<0.001**
Mental Health	-4.24 (0.93)	-.32 (.07)	-4.57	**<0.001**	-3.98 (0.92)	-.30 (.07)	-4.32	**<0.001**	-4.06 (0.92)	-.31 (.07)	-4.39	**<0.001**
Gender	-0.23 (0.79)	-.02 (.06)	-0.30	0.767	-0.26 (0.79)	-.02 (.06)	-0.33	0.744	-0.25 (0.79)	-.02 (.06)	-0.31	0.756
Synchrony					63.81 (28.90)	.16 (.07)	2.21	**0.027**	60.06 (29.95)	.15 (.08)	2.01	**0.045**
Poverty status.									0.81 (1.16)	.05 (.07)	0.69	0.487
Parenting status									-0.25 (0.99)	-.02 (.08)	-0.25	0.802

Random Effects

σ^2	29.43	29.48	29.46
τ_{00}	8.47 CoupleID	7.31 CoupleID	7.21 CoupleID
ICC	0.22	0.20	0.20
N	99 CoupleID	99 CoupleID	99 CoupleID
Marginal R^2 / Cond R^2	0.107 / 0.306	0.135 / 0.306	0.137 / 0.307
log-Likelihood	-622.239	-619.864	-619.580

Note: Note: Model 3 was the best fit model and the one from which interpretations were made.

Table 10. Dependent Variable is Emotional Intimacy at 1-Month Post-Intervention

Predictors	Model 2				Model 3				Model 4			
	Est.	β (SE)	t	p	Est.	β (SE)	t	p	Est.	β (SE)	t	p
(Intercept)	35.85 (0.87)		40.98	**<0.001**	35.77 (0.86)		41.55	**<0.001**	35.94 (1.01)		35.76	**<0.001**
Mental Health	-4.49 (1.00)	-.37 (.08)	-4.49	**<0.001**	-4.27 (0.99)	-.35 (.08)	-4.32	**<0.001**	-4.25 (0.99)	-.35 (.08)	-4.28	**<0.001**
Gender	-0.24 (0.80)	-.02 (.07)	-0.30	0.761	-0.28 (0.80)	-.02 (.07)	-0.35	0.728	-0.27 (0.80)	-.02 (.07)	-0.33	0.739
Synchrony					64.90 (32.68)	.17 (.09)	1.99	**0.047**	59.62 (33.65)	.16 (.09)	1.77	0.076
Poverty status.									0.29 (1.21)	.02 (.09)	0.24	0.807
Parenting status									-0.60 (1.08)	-.05 (.09)	-0.56	0.575
Random Effects												
σ^2	22.67				22.78				22.77			
τ_{00}	9.36 CoupleID				8.17 CoupleID				8.08 CoupleID			
ICC	0.29				0.26				0.26			
N	75 CoupleID				75 CoupleID				75 CoupleID			
Marginal R^2 / Cond R^2	0.136 / 0.388				0.167 / 0.387				0.170 / 0.387			
log-Likelihood	-457.070				-455.157				-454.956			

Note: Model 3 was the best fit model and the one from which interpretations were made.

Table 11. Dependent Variable is Constructive Communication at Baseline

Predictors	Model 2				Model 3				Model 3			
	Est.	β (SE)	t	p	Est.	β (SE)	t	p	Est.	β (SE)	t	p
(Intercept)	62.32 (1.95)		31.91	**<0.001**	62.03 (1.94)		32.05	**<0.001**	63.46 (2.48)		25.60	**<0.001**
Mental Health	-8.35 (2.20)	-.25 (.07)	-3.79	**<0.001**	-7.86 (2.19)	-.23 (.07)	-3.58	**<0.001**	-7.98 (2.20)	-.24 (.07)	-3.63	**<0.001**
Gender	-1.89 (1.51)	-.06 (.05)	-1.25	0.761	-1.91 (1.50)	-.06 (.05)	-1.27	0.203	-1.90 (1.50)	-.05 (.04)	-1.27	0.205
Synchrony					164.73 (78.96)	.17 (.08)	2.09	**0.037**	141.38 (81.81)	.14 (.08)	1.73	0.084
Poverty status.									0.08 (3.23)	.00 (.08)	0.02	0.980
Parenting status									-2.73 (2.69)	-.08 (.08)	-1.01	0.310

Random Effects

σ^2	110.54	109.65	109.81
τ_{00}	128.81 CoupleID	123.33 CoupleID	121.27 CoupleID
ICC	0.54	0.53	0.52
N	108 CoupleID	108 CoupleID	108 CoupleID
Marginal R^2 / Cond R^2	0.071 / 0.571	0.103 / 0.578	0.110 / 0.577
log-Likelihood	-847.743	-845.597	-845.079

Note: Model 3 was the best fit model and the one from which interpretations were made.

Table 12. Dependent Variable is Constructive Communication at 1-Month Post-Intervention

Predictors	Model 2				Model 3				Model 4			
	Est.	β (SE)	t	p	Est.	β (SE)	t	p	Est.	β (SE)	t	p
(Intercept)	68.81 (2.26)		30.41	**<0.001**	68.67 (2.25)		30.55	**<0.001**	68.92 (2.71)		25.43	**<0.001**
Mental Health	-10.46 (2.53)	-.32 (.07)	-4.13	**<0.001**	-10.15 (2.53)	-.31 (.08)	-4.01	**<0.001**	-10.26 (2.52)	-.32 (.07)	-4.07	**<0.001**
Gender	-0.61 (1.59)	-.02 (.05)	-0.39	0.70	-0.62 (1.59)	-.02 (.05)	-0.39	0.694	-0.62 (1.59)	-.02 (.05)	-0.39	0.695
Synchrony					128.40 (94.56)	.13 (.09)	1.36	0.175	104.22 (94.83)	.10 (.09)	1.10	0.272
Poverty status.									4.06 (3.45)	.11 (.09)	1.18	0.238
Parenting status									-2.80 (3.08)	-.08 (.10)	-0.91	0.363

Random Effects

σ^2	89.25	89.11	89.42
τ_{00}	135.15 CoupleID	131.26 CoupleID	125.05 CoupleID
ICC	0.60	0.60	0.58
N	78 CoupleID	78 CoupleID	78 CoupleID
Marginal R^2 / Cond R^2	0.108 / 0.645	0.129 / 0.648	0.151 / 0.646
log-Likelihood	-606.527	-605.615	-604.391

Note: Model 2 was the best fit model.

Table 13. Interactional Synchrony Predicting Change in Relationship Quality

	Estimate	B	*t-score*	*p-value*
Relationship Satisfaction (1-Month)				
Intercept	29.23		6.11	**<0.001**
Mental Health Concerns	-3.16	-.10	-1.57	0.117
Gender	1.02	.03	0.69	0.493
Baseline Relationship Satisfaction	0.60	-.65	9.40	**<0.001**
Synchrony	62.01	.07	.97	0.330
Relationship Satisfaction (6-Months)				
Intercept	42.83		7.65	**<0.001**
Mental Health Concerns	-3.90	-.14	-1.70	0.089
Gender	-4.15	-.15	-2.47	**0.013**
Baseline Relationship Satisfaction	-0.44	.50	5.94	**<0.001**
Synchrony	133.98	.17	1.90	0.057
Emotional Intimacy (1-Month)				
Intercept	13.15		6.58	**<0.001**
Mental Health Concerns	-0.97	-.08	-1.25	0.210
Gender	-0.25	-.02	-0.42	0.675
Baseline Emotional Intimacy	0.66	.73	12.02	**<0.001**
Synchrony	5.13	.01	0.22	0.829
Constructive Communication (1-Month)				
Intercept	37.09		8.19	**<0.001**
Mental Health Concerns	-6.38	-.19	-2.83	**0.005**
Gender	0.79	.02	0.55	0.58
Baseline Constructive Communication	0.51	.51	-7.89	**<0.001**
Synchrony	74.54	.07	0.95	0.344

Note: Interactional Synchrony did not significantly predict changes in relationship quality variables at any timepoint for partners who reported on their relationship.
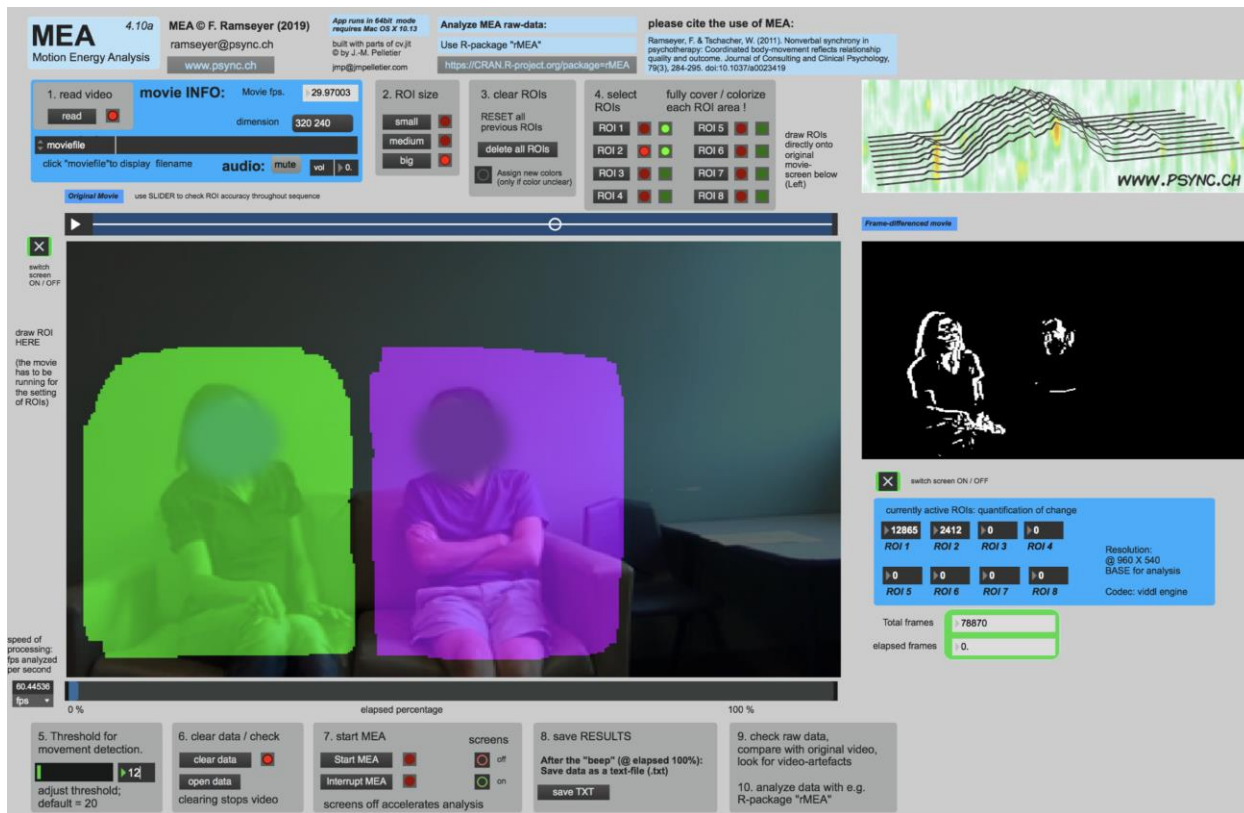
Figures

Figure 1. Motion Energy Analysis Frame Differencing Method (Version 4.10a)
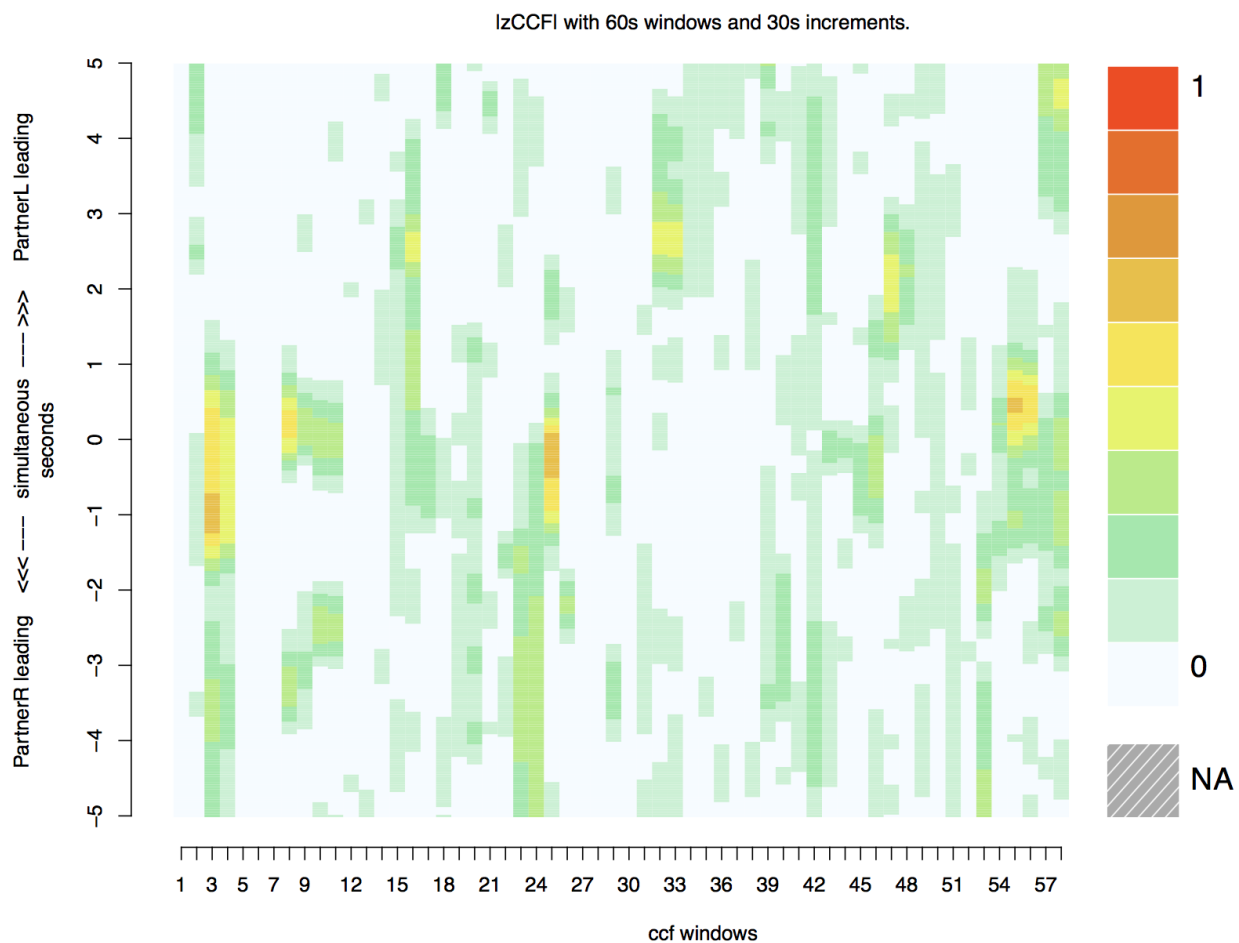
Figure 2. Heatmap of nonverbal behavioral synchrony during a 58-minute video. Cross correlations are calculated in 60 second windows with 30 second increments. Partner L (ROI 1) is the female partner. Partner R (ROI 2) is the male partner. the grand average of the cross-correlation coefficients in each of the 60 windows is the interactional synchrony score.
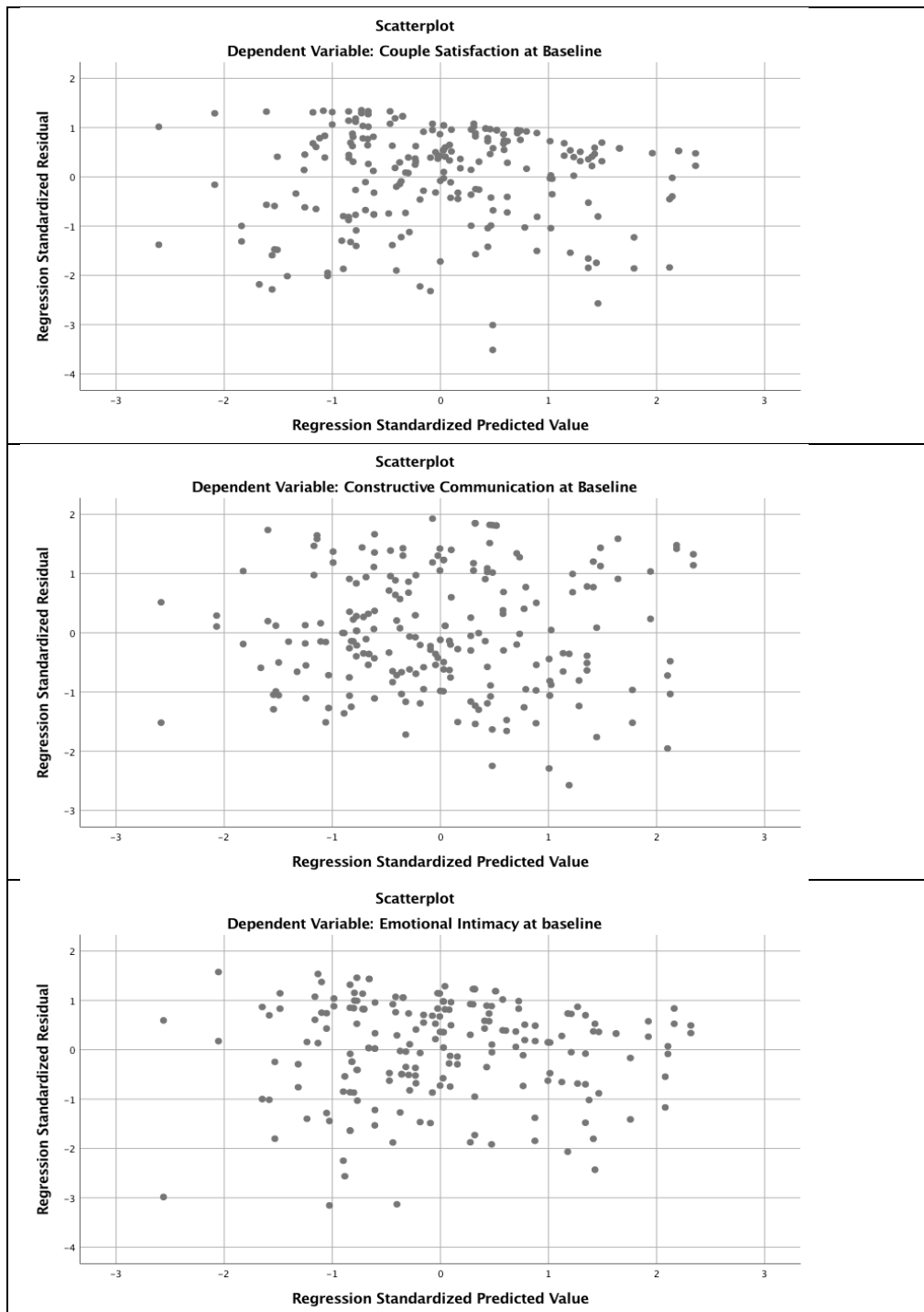
Figure 3. Standardized residuals for Couple Satisfaction, Constructive Communication, and Emotional Intimacy at baseline.
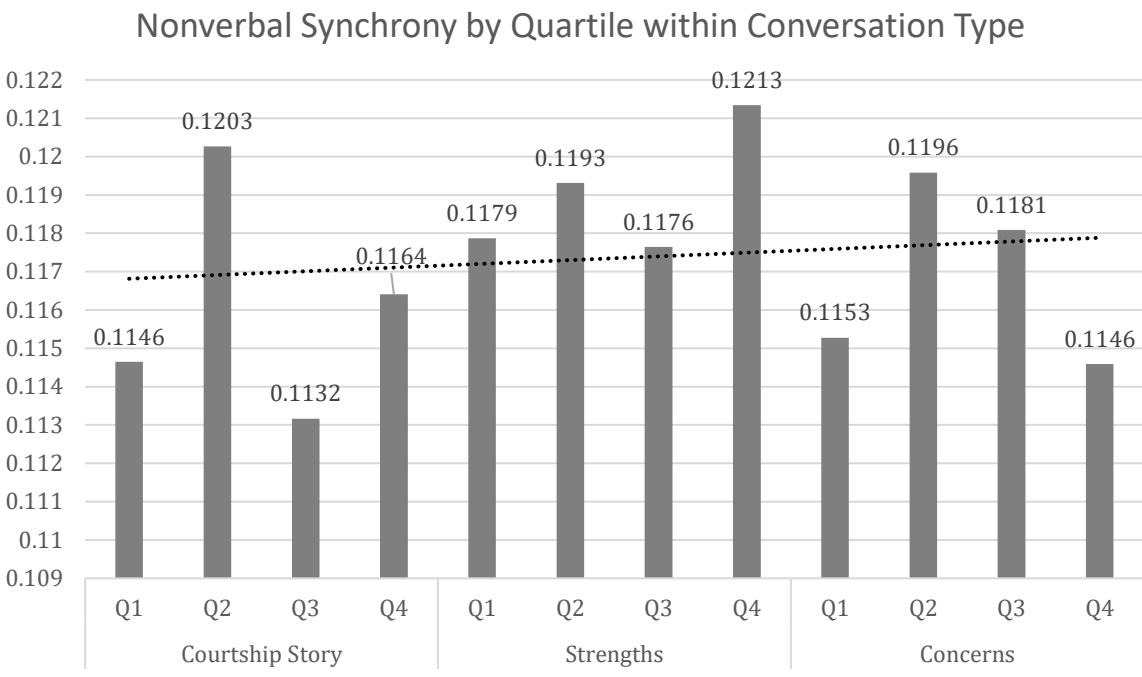
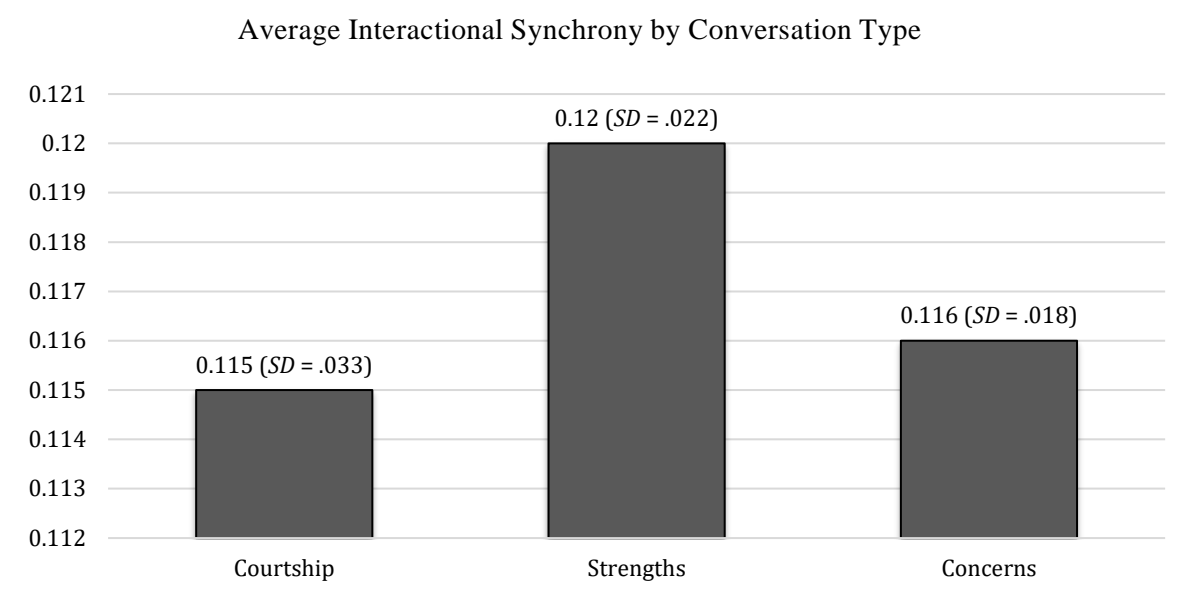Figure 4. Variance of interactional Synchrony by Conversation Type.

Average Interactional Synchrony by Conversation Type

Figure 5. Interactional synchrony during different types of conversations.

Vita

Darren "D.J." Garcia was born in Show Low, Arizona, and spent his formative years moving between Arizona and New Mexico with his single mother and two younger siblings. After graduating from Blue Ridge High School in Lakeside, Arizona, he moved to Flagstaff, Arizona, to manufacture medical devices for W.L. Gore & Associates. Three years later, after converting to Christianity, he took a 2-year employment hiatus to serve as a full-time minister for the Church of Jesus Christ of Latter-Day Saints in the Venezuela Caracas Mission from 2003-2005. At age 26, while working full-time for W.L. Gore & Associates, he earned an Associate degree in Psychology from Coconino Community College. He and his wife, Brenda, then moved to Provo, UT, in 2008, where he took night classes at Brigham Young University (BYU) and eventually earned his B.S. in Psychology in December 2010, graduating with *magna cum laude* honors. D.J. remained at BYU to earn his M.S. in General Psychology in December 2013 under the mentorship of Ross Flom, where his research focused on child development. In the Fall 2014, he was accepted to the Clinical Psychology Doctoral Program at the University of Tennessee, Knoxville, to study romantic couple relationship functioning under his mentor Kristina Coop Gordon. In June 2020, D.J. moved with his wife and 4 children, ages 11, 10, 7 and 4, to Kansas City, Kansas, where he began his yearlong predoctoral clinical internship at the University of Kansas Medical Center. Following the completion of his clinical internship, he plans to graduate with his Doctor of Philosophy degree in December 2021.