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A Multimodal Case Study Utilizing Physiological Synchrony as Indicator of Context in Which Motion Synchrony Is Associated With the Working Alliance

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Interest in the association between patient and therapist's motion synchrony and the working alliance has been growing in recent years. This interest is part of a larger effort in psychotherapy research to study how the working alliance, being central to the therapeutic process, develops over the course of therapy. However, while previous studies suggest that such an association between motion synchrony and the working alliance exists, there are mixed results regarding the direction of it. The present single-case study seeks to shed light on these mixed results with a multimodal perspective of nonverbal synchrony. That is, through an exploration of a single case, the present study explores physiological synchrony as an indicator of context in which motion synchrony is associated with the working alliance. For this aim, a single case was chosen from a randomized control trial investigating short-term psychodynamic treatment for major depressive disorder. Statistical analysis identified an interaction between physiological synchrony and motion synchrony in predicting working alliance levels. Findings show that in the context of an antiphase pattern of physiological synchrony (negative association between physiological measures of the two participants), there was a positive association between motion synchrony and the working alliance. This study emphasizes the potential of a multimodal approach, while suggesting a possible explanation for mixed results in current literature that focuses on the association between motion synchrony and the working alliance.

Clinical Impact Statement

Question: Can physiological synchrony indicate different contexts within therapy sessions, in which motion synchrony's association with the working alliance behaves differently? ***Findings:*** The chosen case study demonstrates that physiological synchrony can indicate different contexts within therapy sessions, in one of which motion synchrony is associated with the working alliance. Antiphase physiological synchrony indicated a context of more engaged talk alongside an association between motion synchrony and working alliance, whereas in-phase physiological synchrony indicated a context of negative partner influence with no association between motion synchrony and working alliance. ***Meaning:*** Merging information from different modalities (physiology, motion, self-report, etc.) is instrumental when learning about the richness of psychotherapy process and specifically when investigating the intricate dynamics of nonverbal phenomenon and its relationship with the therapeutic relationship. ***Next Steps:*** This study is based on a single case, further investigations are required to test whether these findings can be replicated for more patients or perhaps for a specific subgroup of patients.

Keywords: motion synchrony, physiological synchrony, working alliance, multimodal, case study

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In recent years, there has been an increased interest in exploring nonverbal synchrony between patient and therapist, utilizing numerous interdisciplinary approaches (Imel et al., 2014; Kleinbub, 2017; Ramseyer, 2020a). This increased interest is based on decades of research highlighting the central role of a strong working alliance in predicting treatment outcome (Flückiger et al., 2018). The working alliance is commonly defined (Bordin, 1979) as a construct consisting of three components: the emotional bond between the therapist and the patient, agreement on treatment goals, and agreement on how these goals are to be achieved. There is a debate in psychotherapy research on whether alliance functions as a common factor across distinct therapeutic orientations or whether it has a specific active role in treatments that focus on improving the alliance. Recently, it has been suggested that a trait-like aspect of the alliance may have a common facilitating role across distinct treatments, but the state-like strengthening of the alliance may serve as a specific active ingredient in treatment (Zilcha-Mano, 2017). Most of the literature about alliance focused on individual differences between dyads that form strong versus poor alliances (Flückiger et al., 2018) as well as the association between alliance and outcome on a session-to-session basis (Zilcha-Mano, 2021). Much less is known about in-session processes that occur between the patient and the therapist. A better understanding of the phenomenon of nonverbal synchrony within the therapeutic dyad can shed light on the moment-to-moment process of the developing working alliance. Among the most researched modalities of nonverbal synchrony are motion (Ramseyer, 2020a) and physiology (Kleinbub, 2017). A question arises whether investigating these nonverbal synchrony modalities in the context of one another will lead to a deeper understanding of the developing working alliance.

Motion synchrony is one of the most researched modalities of nonverbal synchrony in psychotherapy research (Ramseyer, 2020a). Motion synchrony is defined as coordination in the patient's and therapist's movement (Ramseyer & Tschacher, 2011). According to the concept of embodiment (Ramseyer, 2011), synchronous body movements are thought of as a manifestation of relationship quality. Thus, one could expect that the more the therapeutic dyad's movement is coordinated, the better their relationship quality and working alliance will be. The literature answers this expectation only partly, as there are mixed results regarding the specific direction of association between motion synchrony and the working alliance. While some studies demonstrated that an increase in motion synchrony is associated with a strengthening working alliance (Ramseyer & Tschacher, 2011, 2014), other studies show that an increase in motion synchrony is associated with drops in alliance, specifically alliance ruptures (Deres-Cohen et al., 2021). Thus, the direction of association between motion synchrony and the alliance seems to be changing dynamically, requiring further contextual information to indicate when an increase in motion synchrony levels indicates a strengthening or a weakening alliance. This contextual information may be provided by physiological synchrony.

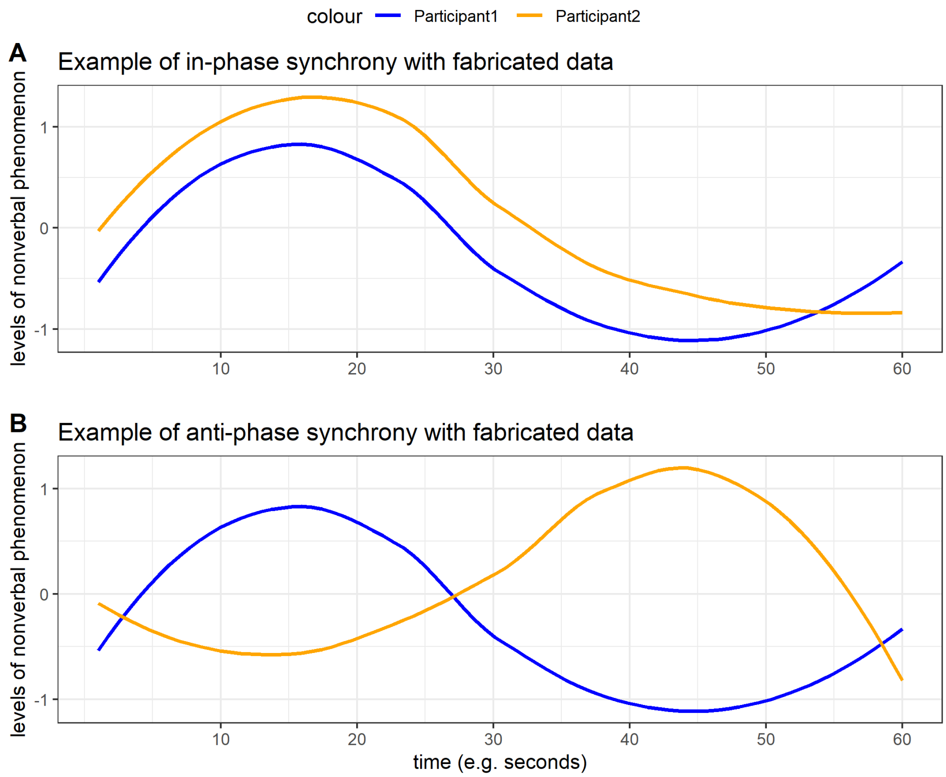
Physiological synchrony is defined as physiological patterns that are shared between two or more interacting participants (Kleinbub et al., 2020). Empirical findings have already established associations between physiological synchrony and central aspects of relationships, such as empathy and emotional regulation (Kleinbub et al., 2020; Palumbo et al., 2017). Physiological synchrony is assumed to be a key component in developing relationships, from mother–infant attachment (Beebe & Lachmann, 2002) to romantic couples (Coutinho et al., 2019). Specifically in psychotherapy, physiological synchrony was previously linked to key aspects of the therapeutic relationship, such as empathy (Kleinbub et al., 2019; Marci et al., 2007), working alliance (Bar-Kalifa et al., 2019; Tschacher & Meier, 2020), and overall relationship quality (Tourunen et al., 2020; see Kleinbub et al., 2020, for a comprehensive review of the literature).

When two or more participants are physiologically synchronized, their physiology can share a similar pattern (in-phase synchrony) or an opposite pattern (antiphase synchrony). An antiphase pattern describes a context when a rise in patient's physiology occurs alongside a decrease in therapist's physiology, or vice versa. An in-phase pattern describes a context when both patient's and therapist's physiology increases, or decreases, at roughly the same time (see Figure 1, for a demonstration with fabricated data). Each of these two patterns were previously shown to correlate with different aspects of the therapeutic relationship, such as therapy progress and relationship quality (Tschacher & Meier, 2020). Importantly, Reed et al. (2013) showed that these two patterns indicated different contexts of conversations between romantic couples. When both partners were engaged in the conversation, and were talking and listening in turns, their physiology (measured by heart rate) followed an antiphase pattern. However, when one partner introduced a negative influence (either demanding toward or withdrawing from their partner), the couple's physiology followed an in-phase pattern. Together, these clinical and empirical findings point to the potential of using physiological synchrony, and specifically contrasting in-phase and antiphase patterns, as an indicator of current context within a therapy session.

The integration of physiological and motion synchrony is in line with the call to develop multimodal markers in psychiatry and psychotherapy research (Clark et al., 2020; Halfon et al., 2021). This approach posits that each modality holds a unique piece of information, and that integrating these pieces of information can reveal a more nuanced picture. Previous studies in different areas of research have shown promising results in employing a multimodal approach, merging information gathered from different modalities to reach conclusions that were not possible beforehand (Joshi et al., 2013; Sharma et al., 2019). For example, while investigating a multimodal approach for an early diagnosis of Alzheimer's disease, researchers demonstrated that merging information from different modalities (neuroimaging, genetics, and clinical tests) raised the accuracy of this very elusive early diagnosis (Venugopalan et al., 2021). In developmental psychology and psychotherapy research, previous studies have already established that there is merit in investigating more than one modality (e.g., motion) of nonverbal synchrony simultaneously. Studies investigating mother–infant interactions have showed that different modalities of nonverbal synchrony are associated with different aspects of the interaction such as proximity or infant affect (Nguyen et al., 2021). Specifically in psychotherapy research, Koole and Tschacher (2016) have proposed a model of interpersonal synchrony (In-Sync model) that posits that the alliance is grounded in coupling of therapist's and patient's brains, manifesting as synchrony in different modalities. Empirical findings have demonstrated that different modalities of nonverbal synchrony are associated with each other (Tourunen et al., 2022), with physiology and

Figure 1

Example of In-Phase and Antiphase Patterns of Synchrony With Fabricated Data



Note. Random noise was added to sine functions to create an example of different patterns of synchrony. Panel A: An in-phase pattern. Panel B: An antiphase pattern. See the online article for the color version of this figure.

motion modalities showing not only an association but a dynamic that changes over time (Gordon et al., 2020). Zooming into a single 6-min segment of a couple therapy session, Kykyri et al. (2019) investigated the association between modalities of nonverbal synchrony and the working alliance. They demonstrated that markers from motion synchrony and physiological synchrony were associated with moments of conversation that had to do with the alliance (e.g., conversation about therapy goals). These findings show the potential of investigating multiple modalities of nonverbal synchrony, by simultaneously demonstrating that different modalities associate with each other, as well as form a dynamic that can be associated with the working alliance.

Building on this promising literature, the present study adopts a multimodal approach to answer the question: In what circumstances is motion synchrony associated with working alliance? We hypothesized that physiological synchrony could serve as an indicator of context in which motion synchrony is differentially associated with working alliance. Because not enough knowledge exists regarding the interaction between motion and physiological modalities of nonverbal synchrony, no directional hypotheses could be derived from the literature. For this reason, a single case was chosen to explore the intricate dynamics between physiological synchrony and motion synchrony, and the association with the working alliance. This study focuses on a single-case study of a female patient receiving psychotherapy as part of a randomized control trial for major depressive disorder (MDD; Zilcha-Mano et al., 2018).

Method

This study is part of a randomized controlled trial for MDD, administering two treatment conditions: supportive and supportive–expressive therapy for depression (Zilcha-Mano et al., 2018). Patients were 18–60 years of age, diagnosed with MDD. Participants provided informed consent prior to participating. Due to COVID-19 difficulties, physiological data from only three patients could be gathered. From these, one patient was chosen for this case study.[1] This patient showed fluctuations in the levels of alliance throughout treatment, which added variance to be explained by physiological and motion synchrony. This case was randomized to receive the supportive condition. In supportive treatment, the working alliance is perceived as the core active ingredient of the therapy, potentially achieved through corrective experience (for further details regarding supportive techniques, see Leibovich et al., 2018).

[1] Physiological data were gathered for three full 16-session therapies before the COVID-19 outbreak. Of these three patients, one had a diagnosed sleep disturbance issue, and another had been drinking coffee during sessions. As caffeine and sleep issues are known to affect heart rate in adults (Grandner et al., 2016; Quinlan et al., 2000), these two were left out of the present study.

Patient

Hannah (all details are obscured), a 25-year-old student of photography, turned to therapy because she suffered from an extremely low mood, self-criticism, and low self-esteem. She had difficulties doing her daily chores and had profound problems with her interpersonal relationships. Her father died when she was a child after a long struggle with medical problems following a traffic accident. Her mother was struggling with mental issues and was not able to take care of her. Thus, as a child, she moved in with a relative (her aunt), who was described as openly hostile toward her. Despite these circumstances, she managed to maintain a good academic performance in school. At the same time, she found it very difficult to trust people and so had very few friends and no long-lasting romantic relationships throughout her life. Hannah turned to the Psychotherapy Research Lab at the University of Haifa, Israel, seeking therapy because she felt lonely without meaningful relationships in her life and hopeless about her future. Upon admittance, Hannah achieved a Hamilton Rating Scale for Depression (HRSD) score of 20 (Hamilton, 1967), and Beck Depression Inventory score of 33 (Beck et al., 1996), and current MDD based on the Mini-International Neuropsychiatric Interview (Sheehan et al., 1998).

Therapist

The therapist was Susan (details are obscured), a female clinical psychologist in her 40s, who treated patients in the randomized control trial (reference to protocol is censored). Susan received comprehensive training in the given short-term dynamic psychotherapy for depression. Training included supervised reading and role-playing. Susan also had a few years of experience in short-term therapy for depression and 15 years of experience as a licensed clinical psychologist providing psychotherapy. Susan received supervision from an expert in supportive–expressive psychotherapy and participated in a group supervision.

Case Formulation

Hannah's case formulation was based on the core conflictual relationship theme (Book, 1998; Luborsky & Crits-Christoph, 1998). The most common wish that Hannah had in interpersonal relationships was to feel accepted, respected, and loved. In her words, she wanted "to feel appreciated and accepted, to feel like I am being loved for who I am" (wish; W). She felt, however, that people disrespect and ignore her (response of other; RO). This gave Hannah a sense of being isolated and detached from others, which eventually led to her feeling depressed, lonely, and hopeless (response of self; RS).

Therapeutic Process

Hannah began her therapeutic process in a delicate emotional state. She was frequently in tears and shared some painful memories from her past childhood. She could not live a normal life with these issues troubling her, as a child as well as an adult. In these early sessions, Susan showed sympathy to Hannah's painful life stories, as well as shared how impressed she was by Hannah's ability to get good grades in school and maintain stability in times of such emotional turmoil, and said: "Despite all you went through, you managed to create a stable life for yourself." Such interventions helped Hannah to better regulate her emotions and to gather the emotional resources to explore her current challenges as a student and in her relationships. This next period of therapy was characterized by spontaneous switching of these two states. In some situations, Hannah was still focused on painful memories about her past, while in other situations, Hannah was less emotionally burdened by painful memories, and focused instead on her current issues, which often included situations when she felt disrespected and ignored. Susan altered her interventions in accordance with Hannah. She still offered hands-on help in soothing and regulating painful emotions in situations when Hannah felt depressed, as well as focused on attempts to actualize Hannah's wish (Leibovich et al., 2018) of feeling accepted and respected. For instance, in one session, Hannah talked about who she chooses to befriend in life, and how she might be too picky and felt guilty about it. In response to that, Susan offered another point of view and pointed out: "You know what you want when you meet someone, and that is very commendable. Not everybody has this ability to be in touch with what they themselves want."

Toward the middle of the therapy, Hannah began showing signs of improvement. During that time, she achieved her lowest HRSD score of 11 (9th session), the only occurrence of a score that is considered below the cutoff of a clinical sample (cutoff = 11.75, Jacobson & Truax, 1992; Rehm & O'Hara, 1985). This improvement did not last long, however. Perhaps because she felt better, Hannah felt ready to take actions in her life that beforehand she was too hesitant about. She made plans to take a trip with some friends for a few days and plans for a date. Unfortunately, Hannah could not fulfill her expectations. Her trip was disappointing, and her date stood her up. This left her depressed again, feeling lonely, and self-critical. Susan persisted in her efforts to sooth and help Hannah regulate her emotional pain.

Toward the end of therapy, Hannah's mood kept fluctuating, while Susan kept her focus on actualizing Hannah's wish of feeling respected and appreciated for who she is. Instead of acting in accordance with Hannah's expectations from others (e.g., disrespecting her), Susan made a point of respecting what Hannah wanted to achieve in different aspects of her life. She complimented her on what she already managed to achieve and sympathized with her pain. This has allowed Hannah to expand her repertoire of expectations from others. At the time of therapy ending, however, Hannah achieved an HRSD score of 18.

Measures

Working Alliance

The working alliance was measured via the Working Alliance Inventory–Short Form: Client version (WAI; Horvath & Greenberg, 1989). A 12-item self-report inventory that is based on a conceptualization of alliance according to Bordin (1979). The patient has answered this inventory immediately after each of the 16 sessions. In this randomized control trial, the internal reliability of the WAI was 0.94.

Nonverbal Synchrony

Nonverbal synchrony was measured twice for each session, once for physiological data (heart rate) and once for motion data

(data acquisition and synchrony calculations are further elaborated in the online Supplemental Material).

Physiological Data Acquisition. Heart rate data were gathered with E4 wristband (Empatica) that include photoplethysmography sensors measuring blood volume pulse (at 60 Hz), from which heartbeats were extracted (for a validation study regarding Empatica's E4 wristband, see Milstein & Gordon, 2020). These sensors monitor cardiac activity via change in skin color due to blood volume differences. Wristbands were worn by the therapist and the patient in every therapeutic session. After each session, data were downloaded from wristbands for further processing and analysis. Beats per minute was extracted from the blood volume pulse signal, for each 15 s of recording, using Heartpy (Heartpy 1.2.6; Van Gent et al., 2019), in Python (Python 3.6.8; Van Rossum & Drake, 2009).

Motion Data Acquisition. Motion data were collected in 25 frames per second via a digital video camera, stationed in a fixed position, equally distanced from each participant. All 16 sessions were videotaped. After recordings, videos were cropped (using Corel VideoStudio software, Ottawa, Ontario, Canada) to include only segments in which the patient and the therapist are seated and engaging in therapeutic conversation (excluding talks regarding arrangements of changes in appointment time, etc.). Motion energy was quantified with motion energy analysis (MEA; Ramseyer, 2020b). Measuring motion energy was performed by measuring the difference in pixel value between consecutive frames.

For each participant (patient or therapist), regions of interest (ROIs) were defined, so that only motion made by the participants would be calculated. MEA allows for a threshold of minimal movement to be defined, meaning that a change between consecutive video frames must be significant enough for MEA to include it in the analysis. In line with Ramseyer (2020a) and Ramseyer and Tschacher (2011), that value was set to 20. Values were standardized and smoothed with a moving average window. Calculations were conducted using rMEA package (Version 1.2.0; Kleinbub & Ramseyer, 2021), in R software environment (Version 4.0.2; R Core Team, 2020).

Quantification of Synchrony. A similar procedure was administered to quantify synchrony with physiological data and motion data. In order to comply with current literature (Bar-Kalifa et al., 2019; Tschacher & Meier, 2020, for physiological synchrony; Ramseyer & Tschacher, 2011, for motion synchrony), synchrony was measured via an averaged value of a cross-correlation procedure within nonoverlapping segments of the session.

Procedure was made up of three phases. First, sessions were divided into segments (see below for further details). Second, a cross-correlation procedure was administered in each segment, and correlation values were *Z*-transformed with Fisher's *Z*-transformation. Third, an average of all correlations was calculated as a measure of synchrony that occurred within that session.

Calculating Synchrony in the Different Modalities. Following the literature in each one of the modalities, a few differences exist in calculating synchrony. First, similar to motion synchrony literature (Ramseyer & Tschacher, 2011), we defined segment length of 1-min with lags of up to ±5 s in motion synchrony calculations. Likewise, and according to physiological synchrony literature (Tschacher & Meier, 2020), and because heart rate was measured in a lower frequency (once every 15 s), we defined segment length of 3-min with lags of up to ±1.5 min in physiological synchrony calculations. Second, in line with Ramseyer and Tschacher (2011) and Tschacher and Meier (2020), and to allow for measurement of in-phase and antiphase synchrony in the case of physiological synchrony, we averaged correlations' absolute values from all segments in motion synchrony and correlations' original values in physiological synchrony. Antiphase was represented as below-zero physiological synchrony.

Comparison to Pseudosynchrony. To control for coincidental synchrony, control data were created to serve as a chance-level synchrony measurement to contrast against (Ramseyer & Tschacher, 2011). This was done first by shuffling the observed data. Two data streams from each of the 16 sessions were pooled together, and all possible combinations of two data streams were used to create "pseudo-sessions." Shuffling resulted in 480 pseudo-sessions (32 choose 2, minus 16 original dyads). Afterward, the same synchrony calculation was administered with these 480 pseudo-sessions. Average synchrony score of all pseudo-sessions (termed pseudosynchrony), as well as the standard deviation, has served as values of coincidental synchrony to contrast against. Finally, we calculated a final index of *Z*-transformed synchrony values for each session, by normalizing the observed synchrony values to the average and standard deviation of pseudosynchrony. This procedure was repeated for both physiological and motion synchrony calculations.

$$(\text{synchrony} - \text{pseudosynchrony})/SD_{\text{pseudosynchrony}}. \qquad (1)$$

Data Analysis

To analyze the association between nonverbal synchrony and the working alliance, we used the PROC MIXED program (Littell et al., 2006) in SAS 9.4 (SAS Institute, 2015). Given that WAI was measured only after each session, the final model entailed a session-level analysis. To model working alliance changes over time, we evaluated the following trend models: linear, linear in log of time, and stability as fixed effects. We started with a model of only fixed intercept and added a fixed effect of time. Next, we examined a model with a fixed effect of log of time. We used the log-likelihood test and the Bayesian information criterion (BIC) to determine whether the inclusion of each term improved the model fit.

We conducted an analysis of three models. Model 1 tested physiological synchrony in each session as a predictor of WAI, Model 2 tested motion synchrony in each session as a predictor of WAI, and Model 3 tested physiological synchrony and motion synchrony in each session, as well as an interaction between them, as predictors of WAI. In all models, we have controlled for time (see online Supplemental Material, for additional exploratory analyses regarding the use of absolute and nonabsolute correlation values).

Results

The session's average length was 50.28 min ($SD = 5.83$). The model that was found to have the best fit based on the BIC for WAI was the one with the fixed effect of log of time (BIC = 21). This model was used in all main analyses (see Table 1, for measured values and Table 2, for summary of analysis results).

Table 1
Measures Throughout Therapy Sessions

Session	PS	MS	WAI
1	2.22	0.74	5
2	−0.53	−0.34	5.33
3	−0.95	0.48	4.25
4	−0.24	0.97	5.08
5	−1.08	−0.14	4.67
6	−0.22	0.38	4.75
7	−1.86	−0.09	4.25
8	−2.57	0.95	4.58
9	−0.74	1.95	5.17
10	−0.89	−0.35	4.17
11	−0.06	0.27	4.17
12	1.77	2.1	4.17
13	−0.01	0.03	4.25
14	−1.72	0.08	4.17
15	0.85	0.48	4.25
16	0.04	−0.06	5

Note. PS = physiological synchrony; MS = motion synchrony; WAI = Working Alliance Inventory score (7-point Likert scale).

The final estimated equation for Model 1 and Model 2 was as follows:

$$y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 \log t_i + \varepsilon_i, \quad (2)$$

where y_i is the value of WAI for session, β_0 is the intercept, x_{1i} is the quantity of physiological synchrony for session i for Model 1, or the quantity of motion synchrony for session i for Model 2, $\log t_i$ is the log value of session i, and ε_i is the residual.

The final estimated equation for Model 3 was as follows:

$$y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{1i} x_{2i} + \beta_4 \log t_i + \varepsilon_i, \quad (3)$$

where y_i is the value of WAI for session i, β_0 is the intercept, x_{1i} is the quantity of physiological synchrony for session i, x_{2i} is the quantity of motion synchrony for session i, $x_{1i}x_{2i}$ is a two-way interaction of physiological synchrony and motion synchrony of session i, $\log t_i$ is the log value of session i, and ε_i is the residual.

Table 2
Analysis Results of All Models

Effect	Estimate	*SE*	*df*	*t* value
Model 1				
Intercept	5.16	0.17	0	29.56
PS	−0.02	0.06	13	−0.29
Logsession	−0.31	0.08	13	−3.68*
Model 2				
Intercept	5.14	0.17	0	29.12
MS	0.08	0.12	13	0.66
Logsession	−0.31	0.08	13	−3.75*
Model 3				
Intercept	5.29	0.1	0	51.95
PS	0.29	0.08	11	3.67*
MS	0.03	0.07	11	0.48
PS × MS	−0.34	0.07	11	−4.56**
Logsession	−0.3	0.05	11	−6.27**

Note. *SE* = standard error; *df* = degrees of freedom; PS = physiological synchrony; Logsession = log of session number; MS = motion synchrony.
* $p < .01$. ** $p < .001$.

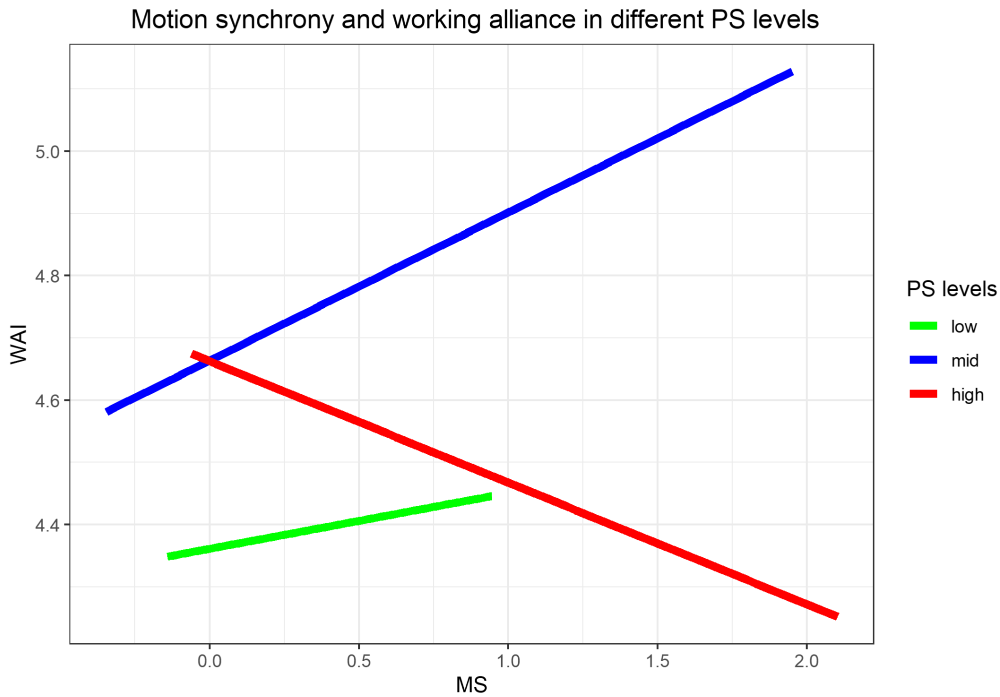
The first two models (Model 1 and Model 2) found small and nonsignificant effects for physiological and motion synchrony, respectively. These effects were not significant in predicting WAI. The main effect for log of session was significant in both models ($B = -0.31$, $SE = 0.08$, $p < .01$, for both models). Although this means that there was a decrease in alliance over time, alliance levels over Hannah's therapy seem to be better described as fluctuating, with the 1st, 2nd, 4th, 9th, and 16th sessions demonstrating higher levels of alliance. In line with the hypothesis, Model 3 has demonstrated a significant interaction effect of physiological synchrony and motion synchrony in predicting WAI ($B = -0.34$, $SE = 0.07$, $p < .001$), as well as a main effect for log of session ($B = -0.3$, $SE = 0.05$, $p < .001$). Specifically, in sessions that were characterized with more antiphase physiological synchrony (i.e., negative association between Hannah's and Susan's physiology), higher quantity of motion synchrony was associated with a stronger working alliance, while in sessions that were characterized with more in-phase physiological synchrony, the quantity of motion synchrony was not associated with working alliance levels (see Figure 2).

Clinical Examples

To shed light on these statistical findings, we performed descriptive analyses (Castonguay et al., 1996) on instances of antiphase and in-phase physiological synchrony within Hannah's sessions, by contrasting examples of high and low alliance levels. For an example of higher levels of working alliance, we chose Session 2, as the session with the highest WAI score (5.33). For an example of lower alliance levels, we focused on the second half of Hannah's therapy, as WAI scores reported for these sessions were lower. From these, we chose two examples that were easiest to describe without going into more detail regarding the full narrative of the therapy and that did not disclose identifiable details of the patient. An example of antiphase synchrony can be presented with a segment from the second session (see Figure 3), which was characterized by higher levels of alliance as reported by Hannah (5.33). In this segment, Hannah began to describe her previous therapy (when she was a child) and how it brought up painful memories she was repressing at the time. In those moments, Susan helped Hannah put what she felt into words, while also sympathizing with her pain. This kind of an empathic reaction helps create a stronger emotional bond between the patient and the therapist, which is an integral part of the working alliance (Bordin, 1979). At those moments of alliance strengthening, a pattern of antiphase physiological synchrony emerged, and a stronger motion synchrony appeared. Following this segment, Hannah shifted her focus toward her accomplishments as a student in school. This was a subject Hannah felt confident about and did not require Susan's empathic reaction as much. In those moments, the physiological synchrony pattern changed to an in-phase one, while motion synchrony faded away. Afterward, Hannah recalled a violent event she witnessed as a child, which again brought tears to Hannah's eyes, and invited Susan to empathize with her. Again, in this segment of strengthening of the emotional bond between the two (and thus the working alliance), a pattern of antiphase physiological synchrony emerged, as well as stronger motion synchrony. In summary, in this clinical

Figure 2

Association of Motion Synchrony and Working Alliance, Within Different Levels of Physiological Synchrony



Note. All 16 sessions of Hannah are presented. Data were split by percentile of physiological synchrony quantity. Middle category contained data from six sessions, whereas low and high categories contained data from five sessions each. Low and middle categories of physiological synchrony are within antiphase range, while high category is within in-phase range. Lines were fitted for each category, demonstrating the trend of the association between motion synchrony and the working alliance. Fitted lines were not allowed to exceed the range of observed data, hence the difference in lines length. Data within the high category were too scattered to conclude there is a negative linear trend, despite the negative slope of the fitted line. MS = motion synchrony; PS = physiological synchrony; WAI = Working Alliance Inventory. See the online article for the color version of this figure.

example, in moments of antiphase physiological synchrony, there was a stronger motion synchrony alongside strengthening of the emotional bond and the working alliance.

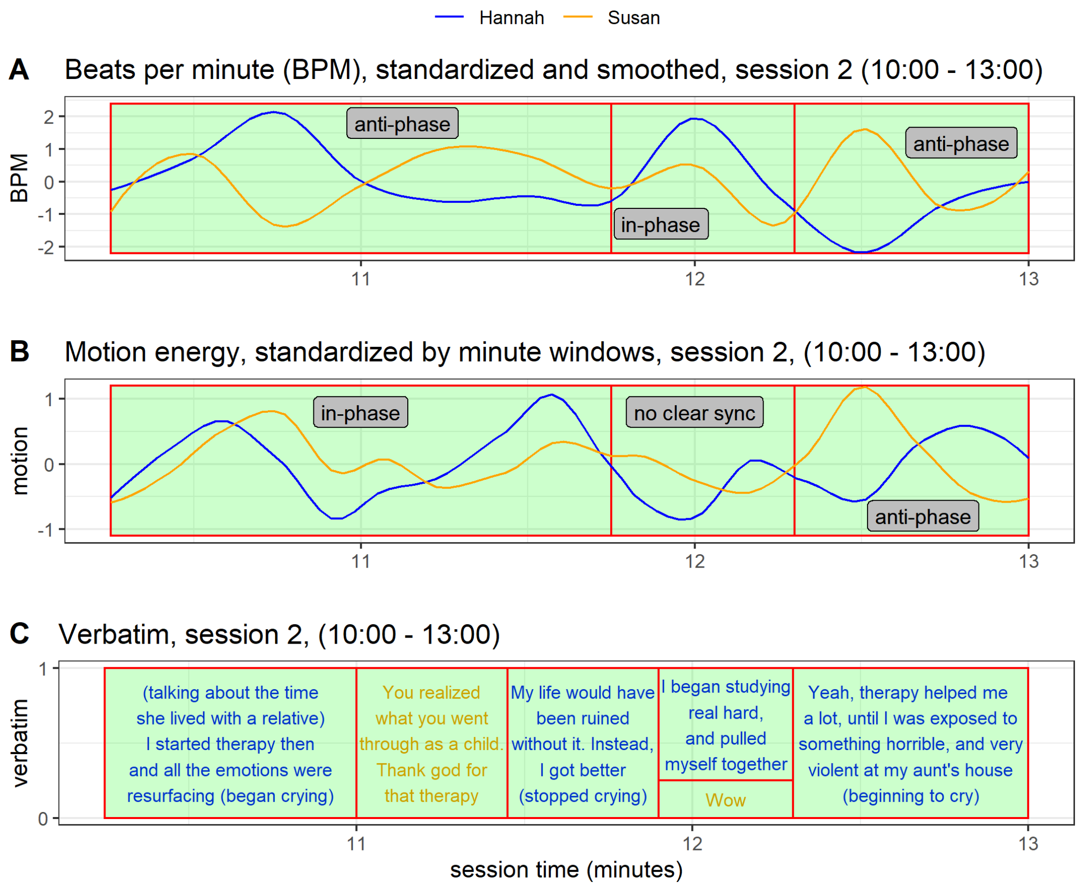
A contrasting example of in-phase physiological synchrony can be presented with a segment from the 13th session (see Figure 4), a session which was characterized with lower levels of alliance (4.25) as reported by Hannah. In this segment, Hannah talked about her anger with her mother who ignored her, and Susan adopted an empowering stance toward her, encouraging Hannah to be more active and to challenge herself. This may have been experienced by Hannah as too demanding, as she withdrew from the conversation and fell silent. Although Hannah and Susan's motion was synchronized in this segment, the verbatim clearly presents fluctuations in the alliance. Importantly, physiological synchrony between Hannah and Susan shows a clear in-phase pattern, which may indicate a context of negative partner influence between the two at those moments (Reed et al., 2013). Without this indication of context from the physiological modality, this would have been a segment in which motion synchrony occurs alongside a fluctuating alliance. In summary, in this clinical example, in-phase physiological synchrony indicated a context in which motion synchrony, although present, was not associated with the working alliance.

Discussion

The present study explored the association between nonverbal synchrony and the working alliance. Motion synchrony was previously shown to be associated with the working alliance, albeit in different directions, suggesting that the direction of association may depend on the context. Therefore, this study examined whether physiological synchrony could provide contextual information to explain these mixed results. Findings suggest that an antiphase pattern of physiological synchrony indicated a context in which motion synchrony and alliance were associated, whereas an in-phase pattern of physiological synchrony indicated a context in which this association was absent. Clinical examples demonstrated that antiphase physiological synchrony indicated a context of a more engaging conversation between Hannah and Susan, in which Hannah, for example, shared a painful memory and Susan responded empathically to her. In the context of these moments, motion synchrony occurred alongside a strengthening alliance. In contrast, in-phase physiological synchrony indicated a context in which Hannah and Susan demanded something from the other or withdrew from one another. In the context of these moments, motion synchrony occurred alongside a fluctuating alliance.

Figure 3

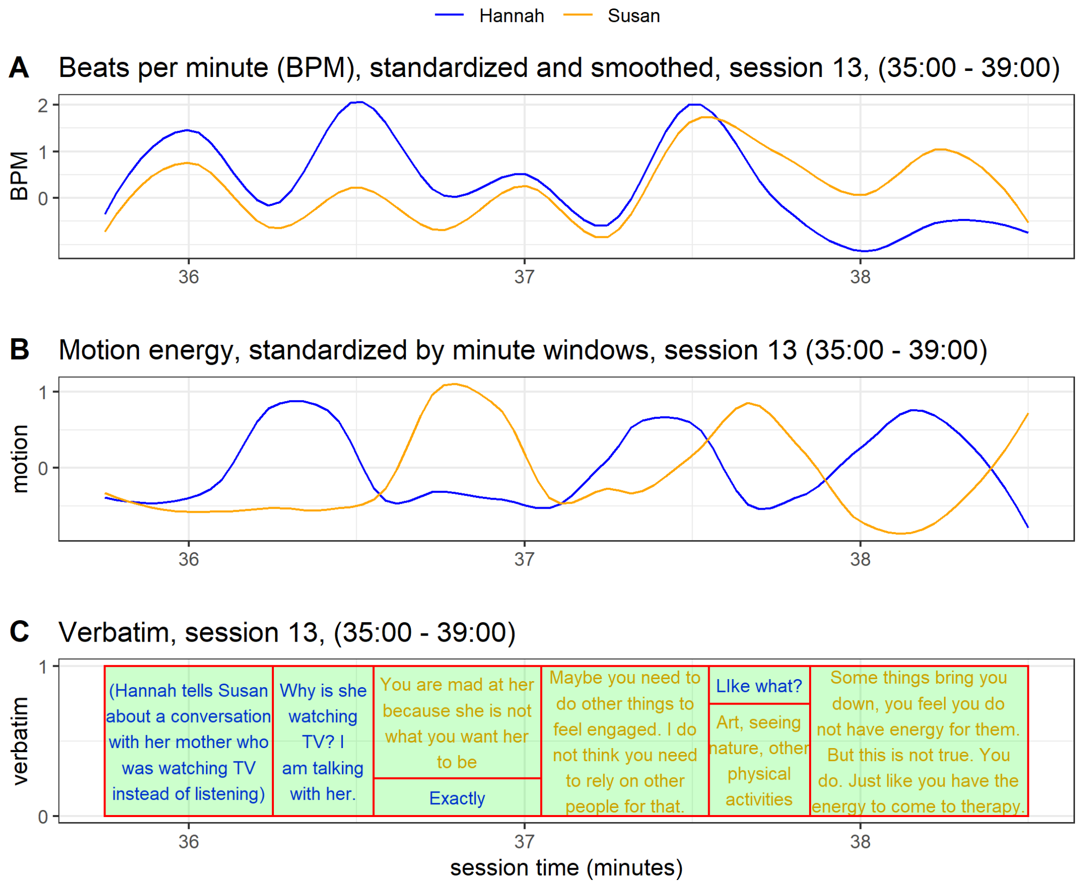
Multimodal Description of a Segment From Hannah's Second Session



Note. Three minutes of Hannah's second session are presented, from the 10th min to the 13th min. Panel A: Hannah's and Susan's heart rate, as standardized and smoothed values of beats per minute. Panel B: Hannah's and Susan's motion energy, standardized by minute windows to correspond with how motion synchrony is quantified. Panel C: Verbatim of the discourse between Hannah and Susan throughout the segment. All figures have a shared *x*-axis of time (as minutes) in the session. As this example contains different subsegments, red lines were added as divisions, with a gray text tag detailing the pattern apparent in each subsegment. Subsegments were delineated by visual inspection. Correlation between Hannah's and Susan's heart rates in each subsegment was −0.6, 0.76, and −0.7, in order from left to right. See the online article for the color version of this figure.

These findings can contribute to the current literature investigating the association between motion synchrony and the working alliance in two major aspects, by emphasizing the importance of the context and by elaborating on situations in which motion synchrony is perhaps not associated with alliance. Initially, these findings shed light on current discrepancies in the literature (Deres-Cohen et al., 2021; Ramseyer & Tschacher, 2011) by stressing the importance of the context in which motion synchrony occurs. The findings of this case are consistent with literature already emphasizing the importance of context to the association between nonverbal synchrony and the alliance. A study by Bar-Kalifa et al. (2019) contrasting cognitive–behavioral interventions with experiential, emotion-focused interventions, demonstrated that only in the context of emotion-focused intervention, physiological synchrony was associated with the therapeutic bond (a component of the alliance). Regarding motion synchrony specifically, it was recently suggested that at the dyad level, when investigating session-by-session, the association between motion synchrony and the working alliance is not as simple as once hypothesized. Quantity of motion synchrony may not always be associated with working alliance levels (Ramseyer, 2020a). Hannah's case demonstrated this, as motion synchrony alone did not predict alliance levels. However, the quantity of motion synchrony was indeed associated with working alliance levels in specific contexts that were identified once physiological synchrony was added to the model. Even if these findings will prove difficult to replicate at the sample level, it still demonstrates a possible dynamic that may be relevant to Hannah and more patients. Other patients may show other dynamics of associations and clustering patients into clusters of these dynamics can be of interest for future research. Thus, this study addresses the call to merge different modalities of nonverbal synchrony to enrich our understanding of the intricate dynamics that unfold within the therapeutic session (Ramseyer, 2020a).

Figure 4
Multimodal Description of a Segment From Hannah's 13th Session



Note. Three minutes of Hannah's 13th session are presented, from the 35th min to the 39th min. Panel A: Hannah's and Susan's heart rate, as standardized and smoothed values of beats per minute. Panel B: Hannah's and Susan's motion energy, standardized by minute windows to correspond with how motion synchrony is quantified. Panel C: Verbatim of the discourse between Hannah and Susan throughout the segment. All figures have a shared *x*-axis of time (as minutes) in the session. Correlation between Hannah's and Susan's heart rates in this segment was 0.53. See the online article for the color version of this figure.

Another aspect in which these findings contribute to the literature of motion synchrony is by giving examples of moments in sessions in which motion synchrony is not associated with the alliance. It was recently suggested that in addition to a strengthening of the alliance, motion synchrony may at other times indicate an effort by one side of the interaction (e.g., therapist) to adapt to the other side (e.g., patient), a mechanism perhaps occurring even more often when the alliance is weakening (Ramseyer, 2020a). Including physiological information perhaps allowed the detection of these different mechanisms, by differentiating a context of engaged conversation between Hannah and Susan (antiphase physiological synchrony) and a context of negative partner influence (in-phase physiological synchrony). In the context of engaged conversation, Hannah and Susan were perhaps already effortlessly adapted to one another, which resulted in higher quantity of motion synchrony alongside a strengthening of the alliance. In the context of negative partner influence, however, one side of the conversation was perhaps trying to adapt to the other, which resulted in higher motion synchrony alongside a weakening alliance. Future studies may profit from focusing on properties of different contexts indicated by different modalities of nonverbal synchrony, and how they interact with each other.

This study adopts a multimodal approach, in which information from one modality is studied together with information from other modalities to reveal a more nuanced picture. In the same manner that multiple color channels are required to assemble a whole picture, multiple channels of information may be required when trying to understand a complex phenomenon such as nonverbal synchrony and its association with the working alliance. With information gathered from only one channel, quantity of motion synchrony, for example, we are witnessing only a single aspect of the whole picture, and can reach only limited conclusions, or perhaps mixed results due to the unknown context of the observed data. This study has focused on a case in which each modality proved to hold insufficient information, while together both modalities demonstrated a dynamic that is associated with the working alliance.

This study has potential clinical implications as well. First, the findings demonstrate how important it is for therapists to stay open for information from a variety of sources. For example, if the therapist notices that the motion energy both they and their patient are exerting have increased in the last few minutes, they would still be advised not to hastily conclude the meaning of this increase, but rather stay open for other sources of information. In turn, this will allow the therapist to better understand if what is currently happening in a session is positive or negative for the therapy. Second, investigating the interplay between modalities of nonverbal synchrony may lead to future developments of feedback systems for therapists. Such systems could potentially consider multiple modalities of nonverbal synchrony alongside other sources of information and provide feedback to therapists regarding their developing relationship with their patients.

It is important to treat these findings with caution, as there are several limitations to consider. First, these findings are based on a single case with only 16 points of measurements, other cases might not demonstrate the same dynamic between physiological synchrony, motion synchrony, and the working alliance. Still, for the case of patients like Hannah, these findings are potentially relevant. Second, different variables were measured with different time resolutions. As working alliance was measured once per session, our findings are limited by a session-level analysis. Clinical examples did zoom into segments within sessions, however, only anecdotally and not systematically. Additionally, motion data were sampled more frequently than heart rate data. This meant that motion synchrony was perhaps more sensitive than physiological synchrony to short-term changes in the session. While processing of the data was designed to answer current gaps in the literature and therefore follow previously published methodologies, future studies are encouraged to aspire to similar time resolutions of measurements. This will allow thorough investigation of the association between nonverbal synchrony and the alliance, as well as to delve into within-session dynamics of different modalities of nonverbal phenomena. Third, we followed the literature in each modality (Ramseyer & Tschacher, 2011; Tschacher & Meier, 2020) in preprocessing the data. Future studies may suggest harmonized methods to be used in multimodal research in psychotherapy. For example, some studies used a cross-correlation procedure, choosing the average of correlations' absolute values (Paulick et al., 2018; Ramseyer, 2020a; Ramseyer & Tschacher, 2011, 2014), or the maximum correlation value (Bar-Kalifa et al., 2019) as a measure of synchrony quantity in a session or a segment. Other studies apply a comparison of linear local slopes (Marci et al., 2007). Further research is required to systematically investigate the influence of these methodological choices (for an example of such systematic empirical investigation in physiological synchrony, see Tschacher & Meier, 2020). Finally, respiratory behavior was not measured, and thus we were not able to consider the influence of breathing on heart rate (Sroufe, 1971). Future studies are encouraged to include respiratory activity in multimodal analyses of nonverbal synchrony, especially when physiology is involved.

The present case study demonstrates the potential of adopting a multimodal approach when investigating the association between nonverbal synchrony and working alliance. As demonstrated by the statistical analysis of this case, physiological synchrony provided contextual information for the association between motion synchrony and the working alliance. If replicated, these findings can help understand mixed results in current motion synchrony literature. Even if these findings would prove difficult to replicate in future studies, this case study already serves as an example of the abundance of unexplored territories in nonverbal synchrony research and its potential to shed light on the therapeutic process as it unfolds.

References

Bar-Kalifa, E., Prinz, J. N., Atzil-Slonim, D., Rubel, J. A., Lutz, W., & Rafaeli, E. (2019). Physiological synchrony and therapeutic alliance in an imagery-based treatment. *Journal of Counseling Psychology*, *66*(4), 508–517. https://doi.org/10.1037/cou0000358

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). *Manual for the beck depression inventory-II*. Psychological Corporation.

Beebe, B., & Lachmann, F. (2002). Organizing principles of interaction from infant research and the lifespan prediction of attachment: Application to adult treatment. *Journal of Infant, Child, and Adolescent Psychotherapy*, *2*(4), 61–89. https://doi.org/10.1080/15289168.2002.10486420

Book, H. E. (1998). Introduction to the brief psychodynamic psychotherapies and the CCRT method. In H. E. Book (Ed.), *How to practice brief psychodynamic psychotherapy: The core conflictual relationship theme method* (pp. 1–18). American Psychological Association. https://doi.org/10.1037/10251-001

Bordin, E. S. (1979). The generalizability of the psychoanalytic concept of the working alliance. *Psychotherapy*, *16*(3), 252–260. https://doi.org/10.1037/h0085885

Castonguay, L. G., Goldfried, M. R., Wiser, S., Raue, P. J., & Hayes, A. M. (1996). Predicting the effect of cognitive therapy for depression: A study of unique and common factors. *Journal of Consulting and Clinical Psychology*, *64*(3), 497–504. https://doi.org/10.1037/0022-006X.64.3.497

Clark, S. R., Cearns, M., Schubert, K. O., & Baune, B. T. (2020). Multimodal modeling for personalized psychiatry. In B. T. Baune (Ed.), *Personalized psychiatry* (pp. 521–536). Academic Press. https://doi.org/10.1016/B978-0-12-813176-3.00043-2

Coutinho, J., Oliveira-Silva, P., Fernandes, E., Gonçalves, O. F., Correia, D., Perrone Mc-Govern, K., & Tschacher, W. (2019). Psychophysiological synchrony during verbal interaction in romantic relationships. *Family Process*, *58*(3), 716–733. https://doi.org/10.1111/famp.12371

Deres-Cohen, K., Dolev-Amit, T., Peysachov, G., Ramseyer, F. T., & Zilcha-Mano, S. (2021). Nonverbal synchrony as a marker of alliance ruptures. *Psychotherapy*, *58*(4), 499–509. https://doi.org/10.1037/pst0000384

Flückiger, C., Del Re, A. C., Wampold, B. E., & Horvath, A. O. (2018). The alliance in adult psychotherapy: A meta-analytic synthesis. *Psychotherapy*, *55*(4), 316–340. https://doi.org/10.1037/pst0000172

Gordon, I., Gilboa, A., Cohen, S., & Kleinfeld, T. (2020). The relationship between physiological synchrony and motion energy synchrony during a joint group drumming task. *Physiology & Behavior*, *224*, Article 113074. https://doi.org/10.1016/j.physbeh.2020.113074

Grandner, M. A., Alfonso-Miller, P., Fernandez-Mendoza, J., Shetty, S., Shenoy, S., & Combs, D. (2016). Sleep: Important considerations for the prevention of cardiovascular disease. *Current Opinion in Cardiology*, *31*(5), 551–565. https://doi.org/10.1097/HCO.0000000000000324

Halfon, S., Doyran, M., Türkmen, B., Oktay, E. A., & Salah, A. A. (2021). Multimodal affect analysis of psychodynamic play therapy. *Psychotherapy Research*, *31*(3), 402–417. https://doi.org/10.1080/10503307.2020.1839141

Hamilton, M. (1967). Development of a rating scale for primary depressive illness. *British Journal of Social and Clinical Psychology*, *6*(4), 278–296. https://doi.org/10.1111/j.2044-8260.1967.tb00530.x

Horvath, A. O., & Greenberg, L. S. (1989). Development and validation of the Working Alliance Inventory. *Journal of Counseling Psychology*, *36*(2), 223–233. https://doi.org/10.1037/0022-0167.36.2.223

Imel, Z. E., Barco, J. S., Brown, H. J., Baucom, B. R., Baer, J. S., Kircher, J. C., & Atkins, D. C. (2014). The association of therapist empathy and synchrony in vocally encoded arousal. *Journal of Counseling Psychology*, *61*(1), 146–153. https://doi.org/10.1037/a0034943

Jacobson, N. S., & Truax, P. (1992). Clinical significance: A statistical approach to defining meaningful change in psychotherapy research. In A. E. Kazdin (Ed.), *Methodological issues & strategies in clinical research* (pp. 631–648). American Psychological Association. https://doi.org/10.1037/10109-042

Joshi, J., Goecke, R., Alghowinem, S., Dhall, A., Wagner, M., Epps, J., Parker, G., & Breakspear, M. (2013). Multimodal assistive technologies for depression diagnosis and monitoring. *Journal on Multimodal User Interfaces*, *7*(3), 217–228. https://doi.org/10.1007/s12193-013-0123-2

Kleinbub, J. R. (2017). State of the art of interpersonal physiology in psychotherapy: A systematic review. *Frontiers in Psychology*, *8*, Article 2053. https://doi.org/10.3389/fpsyg.2017.02053

Kleinbub, J. R., Palmieri, A., Orsucci, F. F., Andreassi, S., Musmeci, N., Benelli, E., Giuliani, A., & de Felice, G. (2019). Measuring empathy: A statistical physics grounded approach. *Physica A: Statistical Mechanics and Its Applications*, *526*, Article 120979. https://doi.org/10.1016/j.physa.2019.04.215

Kleinbub, J. R., & Ramseyer, F. T. (2021). rMEA: An R package to assess nonverbal synchronization in motion energy analysis time-series. *Psychotherapy Research*, *31*(6), 817–830. https://doi.org/10.1080/10503307.2020.1844334

Kleinbub, J. R., Talia, A., & Palmieri, A. (2020). Physiological synchronization in the clinical process: A research primer. *Journal of Counseling Psychology*, *67*(4), 420–437. https://doi.org/10.1037/cou0000383

Koole, S. L., & Tschacher, W. (2016). Synchrony in psychotherapy: A review and an integrative framework for the therapeutic alliance. *Frontiers in Psychology*, *7*, Article 862. https://doi.org/10.3389/fpsyg.2016.00862

Kykyri, V. L., Tourunen, A., Nyman-Salonen, P., Kurri, K., Wahlström, J., Kaartinen, J., Penttonen, M., & Seikkula, J. (2019). Alliance formations in couple therapy: A multimodal and multimethod study. *Journal of Couple & Relationship Therapy*, *18*(3), 189–222. https://doi.org/10.1080/15332691.2018.1551166

Leibovich, L., Nof, A., Auerbach-Barber, S., & Zilcha-Mano, S. (2018). A practical clinical suggestion for strengthening the alliance based on a supportive-expressive framework. *Psychotherapy*, *55*(3), 231–240. https://doi.org/10.1037/pst0000195

Littell, R. C., Milliken, G. A., Stroup, W. W., Wolfinger, R. D., & Schabenberger, O. (2006). *SAS for mixed models*. SAS Institute.

Luborsky, L., & Crits-Christoph, P. (1998). *Understanding transference: The core conflictual relationship theme method*. American Psychological Association. https://doi.org/10.1037/10250-000

Marci, C. D., Ham, J., Moran, E., & Orr, S. P. (2007). Physiologic correlates of perceived therapist empathy and social–emotional process during psychotherapy. *Journal of Nervous and Mental Disease*, *195*(2), 103–111. https://doi.org/10.1097/01.nmd.0000253731.71025.fc

Milstein, N., & Gordon, I. (2020). Validating measures of electrodermal activity and heart rate variability derived from the empatica E4 utilized in research settings that involve interactive dyadic states. *Frontiers in Behavioral Neuroscience*, *14*, Article 148. https://doi.org/10.3389/fnbeh.2020.00148

Nguyen, T., Abney, D. H., Salamander, D., Bertenthal, B. I., & Hoehl, S. (2021). Proximity and touch are associated with neural but not physiological synchrony in naturalistic mother–infant interactions. *NeuroImage*, *244*, Article 118599. https://doi.org/10.1016/j.neuroimage.2021.118599

Palumbo, R. V., Marraccini, M. E., Weyandt, L. L., Wilder-Smith, O., McGee, H. A., Liu, S., & Goodwin, M. S. (2017). Interpersonal autonomic physiology: A systematic review of the literature. *Personality and Social Psychology Review*, *21*(2), 99–141. https://doi.org/10.1177/1088868316628405

Paulick, J., Deisenhofer, A. K., Ramseyer, F., Tschacher, W., Boyle, K., Rubel, J., & Lutz, W. (2018). Nonverbal synchrony: A new approach to better understand psychotherapeutic processes and drop-out. *Journal of Psychotherapy Integration*, *28*(3), 367–384. https://doi.org/10.1037/int0000099

Quinlan, P. T., Lane, J., Moore, K. L., Aspen, J., Rycroft, J. A., & O'Brien, D. C. (2000). The acute physiological and mood effects of tea and coffee: The role of caffeine level. *Pharmacology Biochemistry and Behavior*, *66*(1), 19–28. https://doi.org/10.1016/S0091-3057(00)00192-1

Ramseyer, F. (2011). Nonverbal synchrony in psychotherapy: Embodiment at the level of the dyad. In W. Tschacher & C. Bergomi (Eds.), *The implications of embodiment: Cognition and communication* (pp. 193–207). Imprint Academic.

Ramseyer, F., & Tschacher, W. (2011). Nonverbal synchrony in psychotherapy: Coordinated body movement reflects relationship quality and outcome. *Journal of Consulting and Clinical Psychology*, *79*(3), 284–295. https://doi.org/10.1037/a0023419

Ramseyer, F., & Tschacher, W. (2014). Nonverbal synchrony of head- and body-movement in psychotherapy: Different signals have different associations with outcome. *Frontiers in Psychology*, *5*, Article 979. https://doi.org/10.3389/fpsyg.2014.00979

Ramseyer, F. T. (2020a). Exploring the evolution of nonverbal synchrony in psychotherapy: The idiographic perspective provides a different picture. *Psychotherapy Research*, *30*(5), 622–634. https://doi.org/10.1080/10503307.2019.1676932

Ramseyer, F. T. (2020b). Motion energy analysis (MEA): A primer on the assessment of motion from video. *Journal of Counseling Psychology*, *67*(4), 536–549. https://doi.org/10.1037/cou0000407

R Core Team. (2020). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. https://www.R-project.org/

Reed, R. G., Randall, A. K., Post, J. H., & Butler, E. A. (2013). Partner influence and in-phase versus anti-phase physiological linkage in romantic couples. *International Journal of Psychophysiology*, *88*(3), 309–316. https://doi.org/10.1016/j.ijpsycho.2012.08.009

Rehm, L. P., & O'Hara, M. W. (1985). Item characteristics of the Hamilton rating scale for depression. *Journal of Psychiatric Research*, *19*(1), 31–41. https://doi.org/10.1016/0022-3956(85)90066-4

SAS Institute. (2015). *Base SAS 9.4 procedures guide*.

Sharma, K., Papamitsiou, Z., & Giannakos, M. (2019). Building pipelines for educational data using AI and multimodal analytics: A "grey-box" approach. *British Journal of Educational Technology*, *50*(6), 3004–3031. https://doi.org/10.1111/bjet.12854

Sheehan, D. V., Lecrubier, Y., Sheehan, K. H., Amorim, P., Janavs, J., Weiller, E., Hergueta, T., Baker, R., & Dunbar, G. C. (1998). The Mini-International Neuropsychiatric Interview (M.I.N.I.): The development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. *Journal of Clinical Psychiatry*, *59*(Suppl. 20), 22–33.

Sroufe, L. A. (1971). Effects of depth and rate of breathing on heart rate and heart rate variability. *Psychophysiology*, *8*(5), 648–655. https://doi.org/10.1111/j.1469-8986.1971.tb00500.x

Tourunen, A., Kykyri, V. L., Seikkula, J., Kaartinen, J., Tolvanen, A., & Penttonen, M. (2020). Sympathetic nervous system synchrony: An exploratory study of its relationship with the therapeutic alliance and outcome in couple therapy. *Psychotherapy*, *57*(2), 160–173. https://doi.org/10.1037/pst0000198

Tourunen, A., Nyman-Salonen, P., Muotka, J., Penttonen, M., Seikkula, J., & Kykyri, V. L. (2022). Associations between sympathetic nervous system synchrony, movement synchrony, and speech in couple therapy. *Frontiers in Psychology*, *13*, Article 818356. https://doi.org/10.3389/fpsyg.2022.818356

Tschacher, W., & Meier, D. (2020). Physiological synchrony in psychotherapy sessions. *Psychotherapy Research*, *30*(5), 558–573. https://doi.org/10.1080/10503307.2019.1612114

Van Gent, P., Farah, H., Van Nes, N., & Van Arem, B. (2019). HeartPy: A novel heart rate algorithm for the analysis of noisy signals. *Transportation*

Research Part F: Traffic Psychology and Behaviour, *66*, 368–378. https://doi.org/10.1016/j.trf.2019.09.015

Van Rossum, G., & Drake, F. L. (2009). *Python 3 reference manual*. CreateSpace.

Venugopalan, J., Tong, L., Hassanzadeh, H. R., & Wang, M. D. (2021). Multimodal deep learning models for early detection of Alzheimer's disease stage. *Scientific Reports*, *11*(1), Article 3254. https://doi.org/10.1038/s41598-020-74399-w

Zilcha-Mano, S. (2017). Is the alliance really therapeutic? Revisiting this question in light of recent methodological advances. *American Psychologist*, *72*(4), 311–325. https://doi.org/10.1037/a0040435

Zilcha-Mano, S. (2021). Toward personalized psychotherapy: The importance of the trait-like/state-like distinction for understanding therapeutic change. *American Psychologist*, *76*(3), 516–528. https://doi.org/10.1037/amp0000629

Zilcha-Mano, S., Dolev, T., Leibovich, L., & Barber, J. P. (2018). Identifying the most suitable treatment for depression based on patients' attachment: Study protocol for a randomized controlled trial of supportive-expressive vs. supportive treatments. *BMC Psychiatry*, *18*(1), Article 362. https://doi.org/10.1186/s12888-018-1934-1

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