Author(s): Coutinho, Joana F.; Penttonen, Markku; Tourunen, Anu; Seikkula, Jaakko; Peräkylä, Anssi; Tschacher, Wolfgang; Kykyri, Virpi-Liisa

Title: Electrodermal and respiratory synchrony in couple therapy in distinct therapeutic subsystems and reflection periods

Year: 2023

Version: Accepted version (Final draft)

Please cite the original version:

Coutinho, J. F., Penttonen, M., Tourunen, A., Seikkula, J., Peräkylä, A., Tschacher, W., & Kykyri, V.-L. (2023). Electrodermal and respiratory synchrony in couple therapy in distinct therapeutic subsystems and reflection periods. Psychotherapy Research, Early online. https://doi.org/10.1080/10503307.2023.2294886

Electrodermal and respiratory synchrony in couple therapy in distinct therapeutic subsystems and reflection periods

Authors: Coutinho, Joana F.; Penttonen, Markku; Tourunen, Anu; Seikkula, Jaakko; Peräkylä, Anssi; Tschacher, Wolfgang; Kykyri, Virpi-Liisa

Preprint of accepted manuscript for the Psychotherapy Research

Coutinho, J. F., Penttonen, M., Tourunen, A., Seikkula, J., Peräkylä, A., Tschacher, W., & Kykyri, V.-L. (2023). Electrodermal and respiratory synchrony in couple therapy in distinct therapeutic subsystems and reflection periods. *Psychotherapy Research*, *Early online*. https://doi.org/10.1080/10503307.2023.2294886

Abstract

Objective: Synchrony in the multi-person context of systemic therapy is a complex and understudied phenomenon. We analyzed respiratory and electrodermal synchronies within a couple therapy system with two therapists to determine whether dyadic subsystems between each client and therapist synchronized differently. We also studied synchrony in reflection periods, in which the therapists discussed the therapy process with clients listening. Finally, we examined the association of synchronies with alliance and outcome. **Method:** A sample of 22 therapy sessions in which electrodermal activity (EDA) and respiration were recorded were analyzed. Self-report measures of session alliance and outcome were obtained. Synchrony computation was based on windowed cross-correlation using surrogate synchrony and segment-wise shuffling of physiological time series. **Results:** The results supported the presence of EDA synchrony for the client-therapist and therapist-therapist dyads but not client-client dyads across entire sessions. No significant synchronies were found for respiration behavior. A similar picture was found in reflection periods. Clients' well-being as well as therapists' alliance ratings were significant predictors of client-client EDA synchrony. **Conclusion:** Our results point to the relational meaning of synchrony and its importance for understanding couple psychotherapy, particularly the reflection periods. Challenges involved in extending synchrony computation to multi-person settings were highlighted.

Keywords: Couple Therapy; Physiological Synchrony; Respiration; Electrodermal Activity; Surrogate synchrony (SUSY)

Clinical or methodological significance of this article: This study analyzed both respiratory and electrodermal synchrony in a couple therapeutic system composed by two therapists. The results highlight the complex nature of synchrony in multi-actor settings, and its importance for the process of mutual regulation between the actors in systemic therapy. Therapist-therapist and client-therapist synchronies in EDA alert clinicians to the importance of a strong working alliance and a shared agenda between the co-therapists and of their alliance to both spouses.

Introduction

Interpersonal Synchrony and its Relevance for Human Interaction

Interpersonal synchrony refers to the temporally coordinated dynamics of the body movement, vocal quality, physiological signals, or other nonverbal indicators of two (or more) interacting individuals (Butler & Randall, 2013). Synchrony is present across a wide range of interactions and contexts of social life and appears to fulfill important social functions (e.g, Jackson et al., 2018; Mogan et al., 2017; Vanutelli et al. 2017). The prevalence and conservation of synchrony in situations as diverse as singing or dancing together, maternal attachment, romantic interaction, empathy towards significant others or strangers (Reddish, Fischer, & Bulbulia, 2013) point to the evolutionary benefits of this phenomenon (Henrich, 2015).

Synchrony may be seen as an indicator of affective alignment and a precursor of deeper emotional understanding, being intimately associated with key dimensions of empathy such as emotional contagion (Ax, 1964; Kaplan & Bloom, 1960). Synchrony thus reflects the process of automatic and unconscious emotional resonance with other´s inner states simulated in one´s own body (Hatfield, Cacioppo, & Rapson, 1994; Hatfield, Rapson, & Le, 2011), allowing to "feel" the other´s experiences. This makes it a key phenomenon for significant human interactions, and particularly for helping relationships such as the psychotherapeutic interaction. Indeed, during dyadic psychotherapy, client and therapist tend to synchronize in nonverbal responses and physiological processes (Koole & Tschacher, 2016). Moreover, there is substantial evidence that in individual therapy synchrony is associated with key aspects of the therapeutic alliance and ratings of the therapy process (Marci et al., 2007; Marci & Orr, 2006; Mende & Schmidt, 2021; Gernert, Nelson, Falkai & Falter-Wagner,2023; Tschacher & Meier, 2020). Thus, the dynamics of synchrony constitute an important

aspect of therapeutic interaction and mutual responsiveness and may additionally be understood as a marker of the therapist´s ability to access the patient´s internal state and co-regulate his/her emotional arousal (Koole & Tschacher, 2016).

Psychophysiological measures such as electrodermal activity (EDA), respiration or heart rate seem to constitute important markers of the implicit interpersonal processes that occur in therapy (Avdi & Seikkula, 2019) and started to be analyzed in a set of studies conducted in the 1950s by Dimascio, Boyd and Greenblatt (1957). Since these seminal studies the literature in the field has substantially grown, yet most of this research on physiological synchrony in psychotherapy has focused on a single modality and on individual therapy (dyadic setting of client and therapist).

Synchrony in Multi-Person Settings

Thus, more research is needed that considers synchronies in different modalities and to examine synchronies in multi-person settings (e.g., couple therapy with two clients and one or two therapists). The present work aims to contribute to fill this gap in the literature by examining respiratory and electrodermal synchrony within a couple therapy system, consisting of two clients (spouses) and two therapists (co-therapists).

Interestingly, the context of couple therapy encompasses two types of interpersonal relationships in which synchrony dynamics are central: the adult attachment relationship (that corresponds to the couple´s romantic relationship), and a corrective attachment relationship (that corresponds to the therapeutic relationship). Thereby the research on synchrony cuts across different attachment relationships throughout a person´s life cycle, which suggests that this phenomenon is continually present across development. In the same way that the development of baby´s affect regulation capacities and attachment security depends on repeated experiences of

adaptative forms of biobehavioral synchrony between infants and their parents (Feldman, 2012; Ham & Tronick, 2009), also in adult attachment relationships synchrony is likely the basis of the individuals´ emotional regulation capacity. In this process of mutual co-regulation each member of the dyad regulates his/her own and the other´s inner states (Butler & Randall, 2013; Timmons, Margolin & Saxbe, 2015).

There are several reasons to assume that physiological synchrony exhibits more complex forms in multi-person settings, such as couple or family therapy, than in dyadic settings. The multi-person context of systemic approaches brings complexity to interactive transactions occurring in therapy and consequently to synchrony phenomena. This complexity derives from the need to establish and maintain several alliances at the same time (Friedlander, Escudero, & Heatherington, 2006): the couple allegiance (the pre-existing trust and alliance between spouses), the working relationship between the two co-therapists, and the dyadic therapeutic alliances between each individual spouse and each therapist (in case two therapists are working with the couple). In couple therapy, the therapist has the challenging task of establishing an alliance both with the individuals (spouses) and with the couple as a unit, as well as with his/her co-therapist (Pinsof & Catherall, 1986). This task of negotiating multiple alliances may get even more difficult because in multi-person settings participants also observe the alliances of other participants (Friedlander et al., 2006). For example, other elements of the system may observe the presence of a “split alliance,” that is, when one spouse's alliance with therapist is significantly closer than the other spouse's, and this might lead to poorer outcomes in couple therapy (Pinsof & Catherall, 1986) or even to dropout (Muñiz de la Peña, Friedlander, & Escudero, 2009).

In sum, the presence of multiple individuals and multiple dyadic combinations makes couple therapy an especially interesting model to study synchrony, but we must

take into consideration the different patterns and the different purposes that synchrony may take in these different subsystems. In this study, we will address this complexity by studying synchronies not only in the entire couple therapy sessions, but also in reflection periods, during which two therapists address talk to each other, while the clients are listening. We assume that since the conversation is organized differently in these periods, this may be reflected in different synchronies between the subsystems and provide new knowledge on the meaning of synchrony in multi-actor settings.

Previous findings of Synchrony in Couple´s Interactions and in Couple Therapy

Romantic dyads constitute a context that has seen an increasing number of studies investigating synchrony, specifically psychophysiological synchrony, has been increasing in the last decade (e.g., Helm, Sbarra, & Ferrer, 2012, 2014; Liu, Rovine, Cousino Klein, Almeida, 2013; Papp, Pendry, Simon, & Adam, 2013; Saxbe et al., 2014; Saxbe & Repetti, 2010, Karvonen et al., 2016; Seikkula et al., 2015). The phenomenon was described as physiological linkage in seminal papers (e.g., Levenson & Gottman, 1983; DiMascio, Boyd & Greenblatt, 1957), which means covariation of the physiological time series of the two interacting partners (Butler, 2011), reflecting the process of reciprocal influence that occurs between spouses at the biological level.

It is important to note that different physiological signals may have different biological and psychological meaning, representing different aspects of interpersonal processes. For example measures such as EDA are linear indexes of sympathetic activity once the eccrine glands, whose activity we are capturing in EDA, are exclusively innervated by the sympathetic division of the ANS. Therefore EDA is usually used as a reliable marker of the salience of a given emotional event independently on its valence, that is, EDA tends to be arousal rather than emotional

specific (Cuthbert et al. 2000; Carvalho et al, 2012; Codispoti, Surcinelli, & Baldaro, 2008).). Thus EDA synchrony is likely to reflect the process of increase in sympathetic arousal that occurs in the individual when he is responding to an emotional trigger elicited by the person he is interacting with (Palumbo et al., 2017; Coutinho et al., 2019). On the other hand, a measure like respiration is a more complex physiological signal, that has both sympathetic and parasympathetic influence (Allen, Varga & Heck, 2023; Hameed et al., 2019|). When considering the respiration cycle the process of inhaling and exhaling may be respectively related with attentional processes focused on the self vs on the other. Moreover this pattern of breathing in and breathing out interacts with the turn taking dynamics during a conversation, so it is important to consider who is talking vs who is listening at a given moment. Interestingly an increasing number of studies show that the relationship between respiration and emotions is bidirectional, not only the emotional state influences our respiratory pattern, but that respiratory pattern influences and stimulates emotional state (Jerath & Beveridge, 2020).

In terms of physiological synchrony between spouses, research conducted either in naturalistic daily interactions or using lab-based couple´s interaction paradigms suggests that the association between synchrony and relationship quality is not linear: both too little or too much synchrony may compromise the couple's functioning (Palumbo et al., 2017; Timmons et al., 2015). While low levels of synchrony may reflect disengagement between partners, very high synchrony levels may reflect processes of conflict escalation and increased autonomic reactivity to the other's negative affect (spiraling synchrony, Gottman, 1990). Thus, once synchrony may emerge in any situation of altered joint emotional states (either caused by empathic engagement or conflict), higher levels of synchrony may reflect an adaptive dyadic

functioning (e.g., Palumbo et al., 2017), but also processes of escalation of negative emotions (e.g., Levenson & Ruef, 1992), depending on the relational context of the couple and its emotional valence and degree of arousal.

As mentioned before, the literature on synchrony in couple therapy settings is still scarce. In this domain the "Relational Mind in Events of Change in Multiactor Therapeutic Dialogues" (hereafter Relational Mind) research project (Seikkula et al., 2015), has put forward a set of innovative studies that analyzed different aspects of interactive embodied attunement, including physiological synchrony, between the different actors of couple therapy contexts. In 2015, Seikkula, Karvonen, Kykyri, Kaartinen and Penttonen used a case example from the Relational Mind dataset to illustrate how autonomic synchrony in multi-actor couple therapy is not a simple phenomenon, but instead a complex dyadic or triadic phenomenon that changes from moment to moment. In this case study, the authors showed that in a co-therapist setting, one therapist will synchronize more with one client; thus, to some extent, two client-therapist pairs may emerge. In another microanalytic case study on alliance formations in couple therapy (Kykyri et al., 2019), simultaneous or nearly simultaneous peaks in the arousal (skin conductance responses), posture and movement mirroring, as well as changes in the participants' regular breathing patterns, such as breath holding, or extremely shallow breathing, were defined as synchrony and integrated in the analyses of the verbal exchange. The study demonstrated that when there were clear markers of alliance in a dyad in verbal exchange, there were also markers of synchrony in one or several nonverbal modalities (posture, movement, SCR, respiration). In addition to that, when a dyad was outside conversational exchange, markers of nonverbal alliance in the form of bodily synchrony were often observed in the same dyad. More recently in another single case study, Avdi and colleagues (2022) used their Partial Directed

Coherence (PDC) method to calculate physiological synchrony of heart rate variability in the third and penultimate sessions. PDC is a frequency domain analysis grounded on Granger causality, thus allowing the establishment of the direction of information flow between isolated pairs of time series. Differently from the classical Granger causality, which estimates interactions in the time domain, PDC estimates the frequency-domain causality in physiological time series. Thus it transforms the time series into the frequency domain and provides time-lagged associations between two participants' multivariate signals, assessing their statistical independence or predictability. Using this approach Avdi and colleagues (2022) found a reduction in physiological synchrony as therapy progressed. This decrease primarily concerned the therapist–client(s) interaction and was interpreted as reflecting progress, in the sense of a decrease in the intensity of negative affects expressed by the clients and the need for therapist empathy, as well as the couple's gradual disengagement from the process of therapy in line with the termination phase.

Another previous work using a concordance index procedure (for an explanation of the concordance procedure see Marci & Orr, 2006; Marci et al., 2007; Messina et al., 2013), found that sympathetic nervous system synchrony, measured via EDA, occurred between participants since the start of couple therapy (Karvonen, Kykyri, Kaartinen, Penttonen, & Seikkula, 2016). The authors found that in the beginning of couple therapy, specifically in the second session, the couple dyads showed the lowest level of EDA synchrony, client-therapist synchrony resembled that in individual psychotherapy, and the co-therapists showed the highest synchrony. Another study that also used an EDA concordance approach, in which twelve different couple therapy processes were analyzed (24 clients, plus 10 therapists, working in pairs; hence, 4 persons per session), found that synchrony between spouses increased toward the end of therapy (Tourunen

et al., 2020). Moreover, this change was associated with a positive linear trend in the female clients' wellbeing during therapy process, which the authors interpreted as evidence that couple therapy can bring spouses closer together on a physiological level.

Interestingly, these results reported by Tourunen et al (2020) of lower synchrony in the beginning compared to the end of therapy (when supposedly the wellbeing of the spouses improved), are consistent with data on synchrony between spouses in laboratory tasks, mentioned earlier. Indeed, both in the classical studies by Levenson and Gottman conducted in the 80´s (Levenson & Gottman, 1983), as well as in our own recent research, EDA synchrony was higher during couples' interactions involving negative emotions (Coutinho et al., 2019). On the other hand, physiological synchrony has been linked with dyadic adjustment in studies of daily life couples' interactions (Timmons et al., 2015), which again is in accordance with the findings of an increase in synchrony as therapy proceeds. This should be due to the adaptive process of mutual regulation of the expression of negative emotions that couple therapy is supposed to foster.

In terms of the multimodal assessment of synchrony, in one of the few attempts to analyze different synchrony modalities in couple therapy, a recent study by Tourunen et al (2022) looked at the relationship between sympathetic nervous system synchrony, movement synchrony, and the amount of speech in couple therapy. Their findings showed that couple therapy participants' synchrony mostly occurred in-phase (in-phase synchrony corresponds to positive correlation values, thus referring to changes in the same direction, for example when one partner´s electrodermal activity (EDA) increases, the other partner's EDA also increases), and that anti-phase synchrony (corresponding to negative correlation values, referring to changes in opposite directions - e.g. that when one person's EDA increased or decreased, the other partner´s EDA did the opposite)

was more common in movement than in sympathetic nervous system activity. Importantly they also found that the extent to which synchrony modalities were linked with each other depended on the roles and relationships of couple therapy, being that in client-therapist dyads synchrony in arousal and movement "walked hand in hand", whereas in client-client or therapist-therapist dyads they were not linked. Finally, more talk time by the therapy participants was associated with anti-phase movement synchrony, meaning that the more time the dyad members talked during the session, the less bodily synchrony they exhibited.

Synchrony in Specific Therapeutic Events: The Reflection Periods

The evidence mentioned above points to the fact that when studying synchrony in multi-person couple therapy settings, another layer of complexity derives from the relational context and specific therapeutic tasks that are being implemented in therapy, mainly through talk. This motivated us to look at this phenomenon during reflection periods, in which the therapists voiced their observations and reflections of the session interactions and conversations. The idea behind events of therapists' reflective talk was originally developed by Andersen (1991), who suggested that in every session, all participants ought to be given opportunities to move from the position of talker to that of a listener. This would both encourage multiple perspectives to be voiced in the social interaction and to facilitate participants to shift between inner (personal) and outer (shared with others) dialogue (Andersen, 1991). In practice this means that during the session, therapists turn to face and address talk to each other, not to their clients, who are invited to listen. This is important since therapeutic conversations largely consist of client's telling. Reflective talk periods provide clients brief but important moments to move away from telling to listening, which creates space for reflection and private

meaning-making (Wahlström, 2006). Studying interpersonal synchrony in reflection periods can provide new important knowledge about the meanings of synchrony, since both the conversational structure (all talking or only therapists talking), the conversational roles of the clients (talker or listener) and the conversational format, differ from other parts of the session. For example, during reflection periods both clients adopt a listener perspective which allows to evaluate whether observing the same external stimuli (here, therapists' speech) manifests as synchrony between clients.

Aims of the Study

In sum the present work aims to gather a comprehensive picture of synchrony in couple therapy, by accomplishing the specific goals listed below.

Our main aim was to analyze interpersonal synchronies both in respiration and in electrodermal activity within a couple therapy system, consisting of two clients (spouses) and two therapists (co-therapists). To do that, we calculated synchronies in the two modalities in six dyads (C1-C2; C1-T1; C1-T2; C2-T1; C2-T2; T1-T2) per each therapy case.

Our research questions were:

1) Are the C-C, C-T and the T-T subsystems differently synchronized in a) respiration and b) in EDA?
2) Are the observed synchronies associated with a) alliance ratings of the participants after the session, and b) with clients' wellbeing ratings reported before each session?
3) How do the distinct dyads synchronize in a) respiration and b) in EDA in reflection periods of the sessions?

Method

Participants

The data of this study were drawn from the Relational Mind research project (Seikkula et al., 2015), in which the aim was to increase understanding of the embodied qualities of couple therapy dialogues by studying attunement and synchrony in multiactor settings. The sample consisted of 22 therapy sessions from 12 different couple therapy cases of the Relational Mind dataset. 24 clients and 10 therapists working in pairs were included in the sample. The clients´ mean age was 43 (range 28 – 61) and therapists' mean age was 52 (range 32–63). The sample included 11 male/female couples and 1 female/female couple. Reasons for seeking therapy included: problems in the couple's relationship, outside the relationship (e.g., with childhood family or relatives), violence in previous relationships, and previous violence in the current relationship. Participants committed to non-violence before the therapy started, and no violence in the relationship occurred during the therapy process.

The mean duration of therapeutic processes was 7.75 sessions (range = 4-24, SD=5.51). Couple therapy was implemented in the Psychotherapy Training and Research Center, University of Jyväskylä, Finland. The seating arrangement resembled a circle around a small table; the couple always sat next to each other, and the co-therapists also sat next to each other (see Figure 1). The aim was to keep the design as "natural" as possible, which meant following the standard procedure in the clinic. The therapists were instructed to work in their normal style, which often tended toward a narrative or dialogical approach. The therapy was not manualized, but it contained reflective discussions between the co-therapists, usually toward the end of each session.

All the sessions were recorded with six video cameras, which was a standard procedure in all therapies in the clinic.

[Insert Figure 1]

ANS measures

During the sessions (2nd and 5th or 6th session of each therapy process), participants' Autonomic Nervous System responses were measured. Electrodermal activity (EDA)was recorded with two pregelled disposable electrodes (Ag/AgCl, AmbuR Neuroline 710, Ballerup, Denmark) from the participant's non-dominant palm, below the first and fourth digits. Skin conductance was determined in microsiemens with a constant voltage of 0.5 V (GSR sensor, Brain Products, Gilching, Germany), the signal was amplified in the DC mode and low-pass filtered at 250 Hz. Respiration was recorded via a fabric belt (Brain-Vision BP-BM-10, Brain Products, Gilching, Germany), which was fastened above the clothes, on the lower chest area.

An amplifier (Brain Products Brainamp ExG 16, Brain Products, Gilching, Germany) was used to amplify EDA and respiration in the DC mode and low-pass filter them at 250 Hz. The data acquisition program BrainVision Recorder, (Brain Products, Gilching, Germany) was used to record EDA and respiration with a sampling frequency of 1,000 Hz. In this study, an electrocardiogram (ECG) was acquired in addition to EDA and respiration. The data for ECG are not reported here. A uniform sampling frequency of 1,000 Hz was employed to ensure the capture of high-frequency components in the ECG. To enhance the computational efficiency of synchrony assessments for EDA and respiration, deliberate down-sampling was applied, reducing the sampling rate to 10 Hz. This reduction provided a temporal resolution equivalent to that achieved in a 1 kHz acquisition for EDA, thereby accommodating the slower

temporal dynamics inherent in respiration (Silva, Salvador, Bota, Fred & Plácido da Silva, 2023). The recorded data was downsampled offline to 10 Hz using a Brain Vision Analyzer (Brain Products, Gilching, Germany) and written to a text file for further analyses.

Questionnaires

Self-report measures were given to clients to rate their wellbeing before each session, and to clients and therapists to rate the working alliance after each session. The following measures were selected, since we wished to follow the standard procedure in the clinic, the measures were short and easy to use, and they provided the therapists immediate feedback of the progress.

Outcome Rating Scale (ORS; Miller, Duncan, Brown, Sparks, & Claud, 2003) was used to assess clients' well-being before each session. We defined the mean of the sum (SUM of both clients as an outcome measure of their overall well-being, with a possible total SUM score of 40, and a clinical cutoff of SUM=25.

Session Rating Scale (SRS; Duncan et al., 2003) assessed the working alliance experience of the participants after each session. The subscales are relationship with the therapists/clients, goals/topics of the session, assessment of the therapeutic approach, overall feeling of the session, and SUM (sum of all scales). The SUM scores reflect the quality of the therapeutic alliance: 39–40 is good, 35–38 is fair, 34 or below represents a poor alliance (Duncan & Miller, 2008). We considered the mean SUM of both therapists, and both clients respectively, as predictors in process-outcome analyses.

Synchrony computation

Interpersonal synchronies for the participants' EDA and respiration (RESP) time series were computed for each therapy session and each of the six dyads of a session (C1-C2; C1-T1; C1-T2; C2-T1; C2-T2; T1-T2) by using the SUSY (Surrogate Synchrony) algorithm (Tschacher & Haken, 2019; available as R-package SUSY). SUSY computes synchrony as windowed cross-correlation based on the two time series of each dyad. The time series were first divided into 60-second segments. The reason for segmentation is firstly to deal with possible non-stationarities such as trends in the time series, and secondly to allow creating surrogates as a control condition. Cross-correlations were computed in each segment in a time lag of +/– 5 seconds, by shifting one of the timeseries stepwise (in 0.1 second steps because of the sampling rate of 10 Hz) in relation to the other one. The cross-correlations were transformed using Fisher's Z and then aggregated within each segment. Synchrony was computed by using the so-called non-absolute values of *Z*, which differentiates between instances when the timeseries correlate positively (indicating in-phase synchrony) or negatively (anti-phase synchrony). Finally, the cross-correlations were aggregated across all segments of a session yielding a single value of synchrony for each dyad and session. To test the strength of the empirically obtained synchronies, segment shuffling was used to create surrogate time series (i.e. time series composed of randomly shuffled segments) on which the same computations were run. These pseudo-synchronies computed from surrogates establish a control condition. For example, in a session lasting 70 minutes, 70 segments are available, from which 70x69=4,830 different surrogates can be derived. The cross-correlations of surrogates thus provide 4,830 surrogate *Z* values for this session. Based on such data, for each dyad and session, an effect size (ES) of synchrony was calculated, defined as the difference of the 'real' *Z* and the mean of all surrogate *Z*,

divided by the standard deviation of the surrogate *Z*. This procedure generated our final measure of synchrony ESnoabs. In other words, our measure of synchrony has integrated the multiple comparisons with surrogates, as it is standardized by the mean and variability of its control values, obtained from the segment-shuffled surrogates. This synchrony measure has the shape of an effect size. As the dataset consisted of 22 sessions, two measures (EDA, RESP), and six dyads, 264 values of ESnoabs were obtained. The dyadic synchrony values can be aggregated per session by averaging over the six different dyadic synchronies of each session, respectively.

Using the SUSY algorithm, the synchrony of the reflection periods was also computed. To account for the shorter durations of these periods, we used shorter segments of 20 seconds for the cross-correlations and the surrogate tests but kept the maximum time lag at +/– 5 seconds. Again, synchrony of reflection periods is represented by the effect sizes ESnoabs against surrogate controls.

Defining, locating, and describing the reflection periods

Three research assistants (psychology students) were trained to identify in each session´s videos all periods in which the co-therapists oriented towards each other and had a short conversation in which they voiced their observations and reflections of the session interactions and clients' telling. During reflection periods, clients were listening, and they did not actively participate in verbal exchange. These periods were easy to identify since the structure of the conversation was changed markedly, and most often the therapists also changed their posture, turned their head to better see and to be able to gaze the co-therapist, and in other ways showed that their orientation was changed from clients to address and listen to a colleague. The end of reflection period was also easy to

observe, since the therapists turned back to face clients and indicated with their verbal and nonverbal behaviors that now it was the clients' turn to comment on what therapists just said.

Starting and ending time of each reflection period were carefully marked to an Excel file, and these time stamps were then aligned to correspond the time of respiration and EDA signals, to enable synchrony computations in reflection periods. All time stamps were double checked before these were used in synchrony computations. In the 22 sessions, 31 reflection periods were identified. Their mean duration was 210 seconds (range 48–912).

Although the conversational structure in reflection periods was clear, we assumed that there would be variation in what the therapists addressed in reflective talks, as well as how the clients responded to these. We also assumed that this variation might be relevant for interpreting synchrony findings in reflection periods. Therefore, for more detailed analysis we selected two reflection periods which seemed to differ from each other. We first looked at the contents and targets of the therapists' talk in these two reflection periods. After that, we used a microanalytic turn-by-turn approach to look at how the spouses relate with the therapists' sayings both during the reflection periods and immediately after these. We looked at both verbal and nonverbal markers of agreement and disagreement. To illustrate some of the variation, transcripts of the conversation and findings of the qualitative analysis were presented in two tables, in which synchrony findings were added, too. Finally, in the integrative phase of the analysis, we compared the two reflection periods and looked at possible connections between the synchrony values and what was observed in the interaction.

Calculation of session-wise synchronies

Synchrony computed by the SUSY algorithm is a dyadic measure. To obtain session-wise synchronies, we averaged the synchrony across all dyads of a session, separately for respiration and EDA. This means, the session synchrony of client-therapist (C-T) synchronies is the average of four dyadic synchrony values, and overall session synchrony the average of six dyadic synchrony values. C-C and T-T synchronies are based on one value per session and thus did not undergo averaging. The significance of synchrony across all 22 sessions was assessed using one-sample *t*-tests of the session-wise synchronies against the expectation value of zero (i.e., no synchrony). This procedure was chosen as all synchronies are expressed as effects sizes ESnoabs, which may obtain positive, negative or zero values, indicating in-phase, anti-phase or no synchrony. It is therefore meaningful to test a sample of synchronies (ESnoabs) against zero to decide if there is significant in-phase ($t>1.96$), anti-phase ($t<-1.96$) or no synchrony. This procedure was validated in a methodological study (Meier & Tschacher, 2021).

Calculation of process-outcome relationships

Session-wise synchrony values were given the role of dependent variables in hierarchical regression models with the ORS and SRS self-report scores as predictors. Synchrony was given in four variables: C-C and T-T synchronies were expressed as ESnoabs-C-C and ESnoabs-T-T, and C-T-synchronies by the ESnoabs of all four client-therapist dyads of each session, and session synchrony (ESnoabs-all) by the mean of all six dyad synchronies of a session. The outcome rating scale (ORS, sum score) and the Session Rating Scale (SRS, clients' and therapists' sum scores) were regressed separately on the C-C, T-T, and C-T synchronies.

The ratings of clients C1 and C2 were aggregated by averaging because C1 and C2 refer to different individuals across sessions, and the ratings of therapists T1 and T2 were aggregated in the same manner, leaving one ORS score (ORS_C-SUM) and two SRS scores (SRS_C-SUM; SRS_T-SUM). The regression procedure was hierarchical using mixed effects models with therapy system (Therapy#) as random effect because twelve therapy systems with identical clients and therapists provided the 22 sessions. The fixed effects were first the clients' ORS_C-SUM sum score, then the clients' SRS_C-SUM sum score, finally therapists SRS_T-SUM sum score. All computations were conducted using JMP Pro 15.1 (SAS Institute Inc., 2019).

Results

Mean synchronies of entire sessions in two modalities

The available session-wise synchrony values were tested against zero using one-sample *t*-tests. The intra-class correlation (ICC) was assessed using random effects models for synchrony with session as the random effect. EDA synchronies had an ICC of 0.15, which was significant in a Wald test. Synchronies based on respiration had an insignificant ICC of 0.07. Across all 22 sessions, we found evidence of in-phase electrodermal synchrony for the client-therapist and therapist-therapist dyads but not for the client-client dyads (Table 1). Regarding respiration behavior none of the synchronies significantly deviated from zero.

[Insert Table 1]

We tested the six session-wise synchronies (ESnoabs-all of EDA and respiration) also separately in each session. Performing one-sample *t*-tests of these synchronies provided four significant in-phase sessions synchronies for EDA and one in-phase session synchrony in respiration (Table 2).

[Insert Table 2]

Mean synchronies of reflection periods in two modalities

Thirty-one reflection periods (Mean duration 210 seconds, range 48–9123) were analyzed. We found significant in-phase electrodermal synchrony across all dyads and for the client-therapist dyads. Regarding respiration behavior no significant synchronies were found (Table 3).

[Insert Table 3]

Describing all 31 reflection periods separately, we tested the respective six dyadic synchronies of each period against zero using one-sample t-tests. Two of the EDA synchronies were significantly larger than zero, suggesting in-phase synchrony in reflection periods J008_5#1 and J012_2#1. Three respiration synchronies deviated significantly from zero, suggesting in-phase synchrony in reflection periods J002_2#1 and J007_2#1, and anti-phase respiration synchrony in J003_5#1.

Process-outcome analyses

Of the eight mixed-effects regression models for the association between clients' well-being before each session (ORS_C-SUM) and the session-wise synchronies between clients (ESnoabs-C-C), therapists (ESnoabs-T-T), and client-therapist dyads (ESnoabs-C-T), and all synchronies of the session (ESnoabs-all), one model showed significant process-outcome associations. Clients' well-being predicted C-C EDA synchrony (Table 4).

[Insert Table 4]

The associations between synchronies and alliance ratings assessed using the SRS (Session Rating Scale) were estimated in analogy to the ORS. The two overall alliance ratings, the clients' sum score SRS_C-SUM and the therapists' sum score SRS_T-SUM were separately regressed on session-wise synchronies. Of the four types of synchronies (ESnoabs-C-C, ESnoabs-T-T, ESnoabs-C-T, ESnoabs-all), one was associated with alliance: electrodermal ESnoabs-C-C was predicted by therapists' alliance self-report (Table 5).

[Insert Table 5]

Illustrative case vignettes: How do clients attune to what therapists say during the reflection periods?

Next, we will present two extracts from two different couple therapy cases to illustrate variations in affiliations and attunements between clients and therapists during the reflection periods, as well as how clients respond to the therapists' reflective talks immediately after these. We will also present synchrony findings for each dyad for both reflection periods.

[Insert Tables 6 & 7 (Reflection period 1 and 2) about here]

Discussion

The goals of the present work were threefold: across all sessions, we intended to examine the presence of synchrony in couple therapy in different modalities and therapeutic subsystems across all sessions; to see whether in reflection periods such

synchronies also occurred; and to analyze the relationship between synchrony and measures of the alliance and outcome.

In terms of the analysis across sessions we found electrodermal (EDA) synchrony but no evidence of respiration synchrony. EDA synchrony was observed in all dyads with the exception of C-C (client-client) dyads. Both C-T (client-therapist) and T-T (therapist-therapist) were synchronized in the same direction (positive correlation, i.e. in-phase synchrony), and T-T synchrony had the highest synchrony levels. These results are consistent with previous work (Karvonen, Kykyri, Kaartinen, Penttonen, & Seikkula, 2016) that also found that synchrony between co-therapists tended to be high. The high synchrony level between co-therapists may reflect their shared orientation and understanding of the couple's situation. In other words, when both therapists deliberately direct their attention to similar features of the clients' speech and behavior, it is likely to get them involved in the same kind of internal process and related patterns of physiological activation. They also need to coordinate their collaboration and for that reason to attune to each other in the session. Likewise, the significant in-phase EDA synchrony in C-T dyads points to the relationship between physiological synchrony and the alliance that is established between each client and each therapist. In sum, both T-T and C-T synchronies in EDA highlight the importance of a strong working alliance and a shared agenda between the co-therapists and of their alliance to both spouses.

At the same time, we found no evidence for EDA synchrony in C-C dyads. This is in accordance with previous studies of the Relational Minds project, in which the C-C values of synchrony measured using the concordance approach were the lowest (Tourunen et al., 2020). A possible interpretation for this is that the feelings of emotional disconnection between partners, which brought them to therapy, may be reflected in the physiological disconnection between them. We think that one of the

goals of couple therapy is to bring spouses closer together also on a physiological level, and that the values of synchrony between spouses may thus increase as therapy proceeds. For example, in concordance indices, synchrony was found to be very low in the beginning but higher at the end of therapy (Tourunen et al., 2020). In this sense the fact that in the present study we grouped together the beginning, and the end of therapy may have masked this phenomenon. In order to test this possibility future research should systematically analyze the synchrony values across the course of sessions.

Regarding the absence of synchrony in respiration this may be related with the multi-person setting under study, in which a synchronized pattern of breathing behavior between partners is less likely to emerge than in dyadic settings. The respiratory pattern is composed of inhaling and exhaling cycles, hence respiratory synchrony requires that partner A coordinates his/her breathing-in and -out behavior in a synchronous way with partner B. In previous work this type of respiration synchrony was reported in dyadic therapy (Tschacher & Meier, 2020) and when an external stimulus was present, such as music in choir singing (Delius & Müller, 2023; Vickhoff et al., 2013).

In fact, measures such as respiration rate (i.e., the frequency of inhalations per minute), EDA or heart rate are more directly linked to autonomic arousal, so that synchrony in such measures may be more expected to emerge each time sympathetically arousing topics (either positive or negative) are discussed. On the other hand, measures such as respiratory behavior which we used in this study may be more affected by talking versus being quiet, and this may explain the lower probability that we capture this type of synchrony.

Another key aspect of synchrony patterns emerging during emotionally arousing topics, specifically regarding the role synchrony plays in the interaction, concerns the direction of synchrony. Previous work suggested that in-phase synchrony may emerge

either in processes of joint positive emotions or in processes of escalation of negative emotions that characterize conflictual interactions (Timmons et al., 2015). For example, in our previous work we found that EDA synchrony was higher during couples' interactions involving negative emotions (Coutinho et al., 2019).

In this respect our findings on the associations between session-wise synchronies and both clients' well-being before each session (using the ORS scale) and participants´ alliance ratings after the session (assessed using the SRS scale) was informative. We found that both clients' well-being as well as therapists' alliance ratings were significant predictors of C-C electrodermal synchrony. Specifically, the synchrony between spouses was negatively related to both the alliance (rated by therapists) and clients´ well-being. Considering that the values of C-C synchrony were negative on average, this means that the more anti-phasic the C-C synchrony was, the higher the clients´ well-being and the stronger the therapeutic alliance rated by the therapists. This may suggest that when partners synchronized in opposite directions, this may signal a positive and adaptative process. Considering that, as mentioned before, high in-phase synchrony can be a sign of competition and escalation (Coutinho et al., 2019), anti-phasic synchrony may on the other hand indicate an adaptative process of mutual regulation of spouses' arousal and thus be associated to clients´ well-being and a good alliance (Coutinho et al, 2020).

As for limitations, both process-outcome associations were found without applying Bonferroni correction considering that we tested EDA synchronies four times against the outcome rating scale and four times against the session rating scale. These tests may be considered rather exploratory, given that the overall sample size was likewise low. We also found no other significant relationships between synchrony and measures of outcome and alliance, as for example an association between C-T

synchrony and therapeutic alliance may be expected. Findings of few significant correlations between alliance and changes in EDA synchrony may suggest that the two phenomena do not overlap to a large extent (Anderson & Johnson, 2010). The absence of strong associations between synchrony and clinical outcome may be due to synchrony reflecting rapidly changing interactional dynamics rather than long-term relationship satisfaction (Nelson et al., 2017). It is also important to note that we did not obtain relational outcome measures such as marital satisfaction or dyadic adjustment in this study, instead we used individual measures of clients' well-being (Anderson & Johnson, 2010). This may also explain the absence of associations with outcome, considering that synchrony as a measure may be rather related with measures of dyadic functioning (Timmons et al., 2015).

Concerning the synchronies across the 31 reflection periods, we found a similar picture to that of the whole sessions. Significant in-phase electrodermal synchrony that was observed only in C-T dyads, and there was no evidence for respiration synchrony. The obvious limitation here was that reflection periods have largely diverging durations. We therefore conducted a post-hoc test in which synchrony values were weighted for the lengths of the respective reflection periods in which they were obtained. The rationale of this weighing was that synchronies of longer periods can be assessed with higher reliability when more segments can be used for estimating the effect sizes of synchrony. Table 3 shows that this effect provided a clearer picture.

No synchrony was observed in C-C dyad, which indicates that listening to the same external stimuli (therapists' talk) alone was not enough to cause synchrony between the spouses. Most probably, this is because the therapists' sayings were given different meanings by each client. The presence of EDA synchrony in C-T dyads indicates that spouses may have become attuned to the content of therapists' reflective

conversation supporting the validity of reflective periods for the clients. Interpreting the selected qualitative extracts of reflection periods allows to see more closely what happened during these conversations. We note that in the extract (Extract 2) with a non-affiliative response of the clients to the reflection, the synchrony values between the clients and therapists were lower. In contrast, the reflection period (Extract 1) where the clients were more attuned to what therapists said and commented on what they heard afterwards, the EDA synchrony was increased. As mentioned before, in systemic therapies such as couple therapy various therapeutic alliances are formed in different subsystems, with each therapist forced to establish an alliance with his/her co-therapist and with each spouse of the couple (Friedlander et al, 2011).

In this work we aimed to contribute to the understanding of the dynamic nature of the alliance formations and related synchronies in multi-actor settings using a multimodal approach by measuring both EDA and respiratory synchrony. However, the complexity inherent to the meaning of synchrony and its role in couple therapy requires the study of several dimensions that should be addressed in future work. For example, to address this complexity, future studies should implement detailed analyses linking the content of the conversation with the synchronies that are established in each dyad. For example, we may see whether spouse A synchronizes with therapist A when he/she is speaking about spouse B, and whether this transient synchrony pattern changes as soon as this same therapist speaks about spouse A. Thus, future work should combine a global macroanalytic approach using bigger samples, with the comparison between different stages of the therapeutic process (initial phase of alliance formation vs last phase of therapy) and the study of specific therapeutic events using microanalytic analysis. We believe that reflective periods as well as other types of therapeutic events, in which the structure or the format of the interaction changes, such as two clients being

in dialogue or rupture-repair episodes can provide new important insights into the relational meanings of synchrony. Finally, from a methodological point of view it could be interesting to compare the results obtained using different methods of synchrony computation (for example SUSY vs concordance index developed by Marci & Orr, 2006 and Tschacher & Meier, 2020).

ETHICAL CONSIDERATIONS

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee of University of Jyvaskyla and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

ACKNOWLEDGMENT SECTION

This work was developed within the Relational Mind in Events of Change in Multiactor Therapeutic Dialogues" research project which has been funded by the Academy of Finland (Grant number 265492) and conducted at the University of Jyväskylä in collaboration with Aristotle University of Thessaloniki, Nordhausen University of Applied Sciences, University of Bern, the Ramon Llull University, University of Helsinki and University of Minho (Psychology Research Centre (CIPsi) supported by the Portuguese Foundation for Science and Technology (FCT; Ref.: UID/PSI/01662/2020) through the Portuguese State Budget.

References

Allen, M., Varga, S., & Heck, D. H. (2023). Respiratory rhythms of the predictive mind. *Psychological Review, 130*(4), 1066.

Andersen, T. (ed.) (1991) The Reflecting Team: Dialogues and Dialogues about the Dialogues. New York: W. W. Norton.

Anderson, S. R., & Johnson, L. N. (2010). A dyadic analysis of the between- and within-system alliances on distress. *Family Process, 49,* 220–235. http://dx.doi.org/10.1111/j.1545-5300.2010.01319.x

Avdi, E., Paraskevopoulos, E., Lagogianni, C., Kartsidis, P., & Plaskasovitis, F. (2022). Studying physiological synchrony in couple therapy through partial directed coherence: associations with the therapeutic alliance and meaning construction. *Entropy*, *24*(4), 517.

Avdi, E., & Seikkula, J. (2019). Studying the process of psychoanalytic psychotherapy: Discursive and embodied aspects. *British Journal of Psychotherapy*, *35*(2), 217-232.

Ax, A. F. (1964). Goals and methods of psychophysiology. Psychophysiology, 1(1), 8–25. https://doi.org/10.1111/j. 1469-8986.1964.tb02616.x

Butler, E. A. (2011). Temporal interpersonal emotion systems: The "TIES" that form relationships. Personality and Social Psychology Review, 15(4), 367–393. https://doi.org/10.1177/1088868311411164

Butler, E. A., & Randall, A. K. (2013). Emotional coregulation in close relationships. *Emotion Review*, *5*(2), 202-210. https://doi.org/10.1177/1754073912451630

Carvalho, S., Leite, J., Galdo-Álvarez, S., & Gonçalves, Ó. F. (2012). The emotional movie database (EMDB): A self-report and psychophysiological study. *Applied Psychophysiology and Biofeedback, 37*(4), 279–294.

Codispoti, M., Surcinelli, P., & Baldaro, B. (2008). Watching emotional movies: Affective reactions and gender differences. *International Journal of Psychophysiology, 69*(2), 90–95.

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.

Coutinho, J., Pereira, A., Oliveira-Silva, P., Meier, D., Lourenço, V., & Tschacher, W. (2021). When our hearts beat together: cardiac synchrony as an entry point to understand dyadic co-regulation in couples. *Psychophysiology* 58:e13739. doi: 10.1111/psyp.13739

Cuthbert, B. N., Schupp, H. T., Bradley, M. M., Birbaumer, N., & Lang, P. J. (2000). Brain potentials in affective picture processing: covariation with autonomic arousal and affective report. *Biological Psychology*, *52*(2), 95–111.

Delius, J. A. M., & Müller, V. (2023). Interpersonal synchrony when singing in a choir [Mini Review]. *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.1087517

DiMascio, A., Boyd, R. W., & Greenblatt, M. (1957). Physiological Correlates of Tension and Antagonism During Psychotherapy: A Study of "Interpersonal Physiology". *Psychosomatic medicine*, *19*(2), 99-104. ´

Duncan, B. L., & Miller, S. D. (2008). 'When I'm good, I'm very good, but when I'm bad I'm better': A new mantra for psychotherapists. *Psychotherapy in Australia*, *15,* 60–69.

Duncan, B. L., Miller, S. D., Sparks, J. A., Claud, D. A., Reynolds, L. R., Brown, J., & Johnson, L. D. (2003). The Session Rating Scale: Preliminary psychometric properties of a "working" alliance measure. *Journal of Brief Therapy*, *3,* 3–12.

Feldman, R. (2012). Parent-infant synchrony: A biobehavioral model of mutual influences in the formation of affiliative bonds. *Monographs of the Society for Research in Child Development*, *77*(2), 42-51.

Friedlander, M. L., Escudero, V., & Heatherington, L. (2006). *Therapeutic alliances in couple and family therapy: An empirically informed guide to practice*. American Psychological Association.

Friedlander, M.L.; Escudero, V.; Heatherington, L.; Diamond, G.M. (2011) Alliance in couple and family therapy. *Psychotherapy*, *48*, 25–33.

Gernert, C. C., Nelson, A., Falkai, P., & Falter-Wagner, C. M. (2023). Synchrony in psychotherapy: High physiological positive concordance predicts symptom reduction and negative concordance predicts symptom aggravation. *International Journal of Methods in Psychiatric Research*, e1978.

Gottman, J. M. (1990). How marriages change. *Depression and aggression in family interaction*, *75*, 101.

Ham, J., & Tronick, E. (2009). Relational psychophysiology: Lessons from mother–infant physiology research on dyadically expanded states of consciousness. *Psychotherapy Research*, *19*(6), 619-632.

Hameed, R. A., Sabir, M. K., Fadhel, M. A., Al-Shamma, O., & Alzubaidi, L. (2019, April). Human emotion classification based on respiration signal. In *Proceedings of the International Conference on Information and Communication Technology*(pp. 239-245).

Hatfield, E., Cacioppo, J. T., & Rapson, R. L. (1994). Emotional contagion. *Current directions in psychological science*, *2*(3), 96-100.

Hatfield, E., Rapson, R. L., & Le, Y. C. L. (2011). Emotional contagion and empathy. *The social neuroscience of empathy.*, 19.

Helm, J. L., Sbarra, D., & Ferrer, E. (2012). Assessing cross-partner associations in physiological responses via coupled oscillator models. Emotion, 12, 748–762.

Henrich, J. (2015). Culture and social behavior. Current Opinion in Behavioral Sciences, 3 84–89

Jackson, J.C., Jong, J., Bilkey, D. *et al.* (2018) Synchrony and Physiological Arousal Increase Cohesion and Cooperation in Large Naturalistic Groups. *Scientific Reports* 8, 127

Jerath, R., & Beveridge, C. (2020). Respiratory rhythm, autonomic modulation, and the spectrum of emotions: the future of emotion recognition and modulation. *Frontiers in Psychology*, *11*, 1980.

Kaplan, H. B., & Bloom, S. W. (1960). The use of sociological and social-psychological concepts in physiological research: A review of selected experimental studies. *The Journal of nervous and mental disease*, *131*(2), 128-134.

Karvonen, A., Kykyri, V.-L., Kaartinen, J., Penttonen, M., & Seikkula, J. (2016). Sympathetic nervous system synchrony in couple therapy. Journal of Marital and Family Therapy, 42, 383–395.

Koole, S. L., and Tschacher, W. (2016). Synchrony in psychotherapy: A review and an integrative framework for the therapeutic alliance. *Frontiers in Psychology* 7:862.

Kykyri, V. L., Tourunen, A., Nyman-Salonen, P., Kurri, K., Wahlström, J., Kaartinen, J., ... & Seikkula, J. (2019). Alliance formations in couple therapy: A multimodal and multimethod study. *Journal of couple & relationship therapy*, *18*(3), 189-222

Levenson, R. W., & Gottman, J. M. (1983). Marital interaction: Physiological linkage and affective exchange. Journal of Personality and Social Psychology, 45(3), 587–597.

Levenson, R. W., & Gottman, J. M. (1985). Physiological and affective predictors of change in relationship satisfaction. Journal of Personality and Social Psychology, 49(1), 85–94.

Levenson, R. W., & Ruef, A. M. (1992). Empathy: A physiological substrate. Journal of Personality and Social Psychology, 63(2), 234–246.

Liu, S., Rovine, M. J., Cousino Klein, L., & Almeida, D. M. (2013). Synchrony of diurnal cortisol pattern in couples. Journal of Family Psychology, 27(4), 579.

Marci, C.D. & Orr, S.P. (2006). The effect of emotional distance on psychophysiologic concordance and perceived empathy between patient and interviewer. *Applied Psychophysiology and Biofeedback*, 31, 115-128.

Marci, C.D., Ham, J., Moran, E., and Orr, S.P. (2007). Physiologic correlates of perceived therapist empathy and social-emotional process during psychotherapy. *Journal of Nervous and Mental Disease,* 195, 103–111.

Mende, M. A., & Schmidt, H. (2021). Psychotherapy in the framework of embodied Cognition—Does interpersonal synchrony influence therapy success?. *Frontiers in Psychiatry*, *12*, 562490.

Messina, I., Palmieri, A., Sambin, M., Kleinbub, J. R., Voci, A., & Calvo, V. (2013). Somatic underpinnings of perceived empathy: The importance of psychotherapy training. *Psychotherapy Research*, *23*(2), 169–177.

Miller, S. D., Duncan, B. L., Brown, J., Sparks, J. A., & Claud, D. A. (2003). The Outcome Rating Scale: A preliminary study of the reliability, validity, and feasibility of a brief visual analog measure. *Journal of Brief Therapy, 2,* 91–100.

Mogan, R., Fischer, R., & Bulbulia, J. A. (2017). To be in synchrony or not? A meta-analysis of synchrony's effects on behavior, perception, cognition and affect. *Journal of Experimental Social Psychology, 72,* 13–20.

Muniz de la Pena, C., Friedlander, M., & Escudero, V. (2009). Frequency, severity, and evolution of split family alliances: How observable are they? *Psychotherapy research*, *19*(2), 133-142.

Nelson, B. W., Laurent, S. M., Bernstein, R., & Laurent, H. K. (2017). Perspective-taking influences autonomic attunement between partners during discussion of conflict. *Journal of Social and Personal Relationships, 34,* 139–165.

Palumbo, R. V., Marraccini, M. E., Weyandt, L. L., Wilder-Smith, O., McGee, H. A., Liu, S. et al. (2017). Interpersonal autonomic physiology: A systematic review of the literature. Personality and Social Psychology Review, 21, 99–141.

Papp, L. M., Pendry, P., Simon, C. D., & Adam, E. K. (2013). Spouses' cortisol associations and moderators: Testing physiological synchrony and connectedness in everyday life. Family Process, 52(2), 284–298.

Pinsof, W. M., & Catherall, D. R. (1986). The integrative psychotherapy alliance: Family, couple and individual therapy scales. *Journal of Marital and Family therapy*, *12*(2), 137-151.

Reddish, P., Fischer, R., & Bulbulia, J. (2013). Let's dance together: Synchrony, shared intentionality and cooperation. *PloS one*, *8*(8), e71182.

Saxbe, D. E., Margolin, G., Spies Shapiro, L., Ramos, M., Rodriguez, A., & Iturralde, E. (2014). Relative influences: Patterns of HPA axis concordance during triadic family interaction. Health Psychology, 33(3), 273.

Saxbe, D., & Repetti, R. L. (2010). For better or worse? Coregulation of couples' cortisol levels and mood states. Journal of Personality and Social Psychology, 98(1), 92.

Seikkula, J., Karvonen, A., Kykyri, V.-L., Kaartinen, J., & Penttonen, M. (2015). The embodied attunement of therapists and a couple within dialogical psychotherapy:

An introduction to the relational mind research project. Family Process, 54, 703–715.

Silva, R., Salvador, G., Bota, P., Fred, A., & Plácido da Silva, H. (2023) Impact of sampling rate and interpolation on photoplethysmography and electrodermal activity signals' waveform morphology and feature extraction. Neural Computing and Applications, 35, 5661–5677.

Timmons, A. C., Margolin, G., & Saxbe, D. E. (2015). Physiological linkage in couples and its implications for individual and interpersonal functioning: A literature review. Journal of Family Psychology, 29(5), 720–731.

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.

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*.

Tschacher W. & Meier D. (2020). Physiological synchrony in psychotherapy sessions, Psychotherapy Research, 30:5, 558-573.

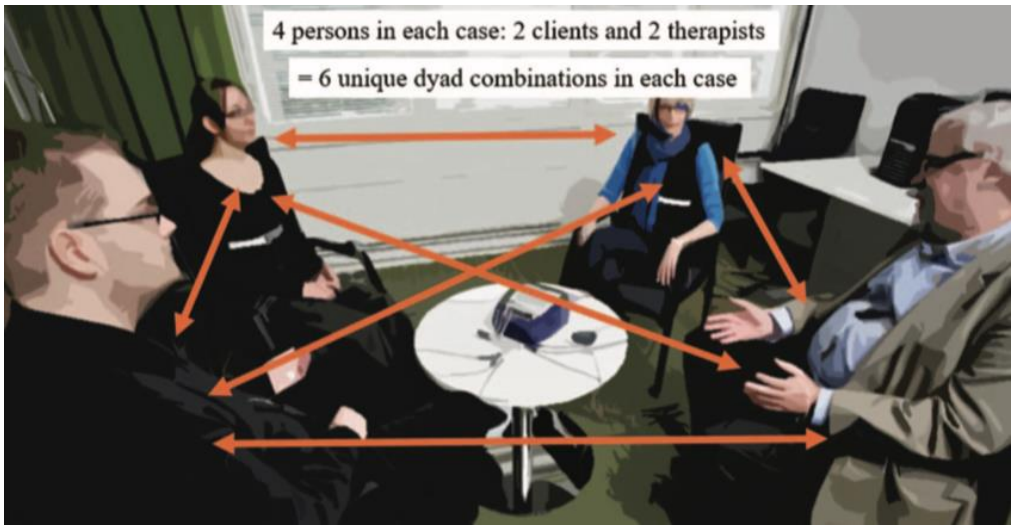
Tschacher W. & Haken H. (2020) Causation and chance: Detection of deterministic and stochastic ingredients in psychotherapy processes, Psychotherapy Research, 30:8, 1075-1087.

Vanutelli, Maria Elide, et al. (2017). Affective Synchrony and Autonomic Coupling during Cooperation: A Hyperscanning Study. *BioMed Research International.*

Vickhoff, B., Malmgren, H., Åström, R., Nyberg, G., Ekström, S. R., Engwall, M., & Jörnsten, R. (2013). Music structure determines heart rate variability of singers. *Frontiers in Psychology*, *4*, 334.

Wahlström, J. (2006). Narrative transformations and externalizing talk in a reflecting team consultation. Qualitative Social Work, 5(3), 313-332.

Figure 1. Therapeutic setting under study



Adapted with permission from Tourunen et al, 2020

Table 1. Mean synchronies (M) and standard deviations (SD) across all 22 sessions for electrodermal activity (EDA) and respiration (RESP)

	EDA		RESP	
all dyads	*M*=29.65 (SD=29.42)	*t*(21)=4.73****	*M*=1.73 (SD=5.19)	*t*(21)=1.57
C-C dyads	*M*= – 7.52 (SD=53.44)	*t*(21)= – 0.66	*M*=1.97 (SD=12.59)	*t*(21)=0.73
C-T dyads	*M*=31.91 (SD=33.32)	*t*(21)=4.49***	*M*=1.21 (SD=8.47)	*t*(21)=0.67
T-T dyads	*M*=57.76 (SD=70.99)	*t*(21)=3.82**	*M*=3.59 (SD=11.28)	*t*(21)=1.49

Note. Parameter setting for synchrony computation: Segment size=60s, maxlag= 5s.
One-sample *t*-tests: ** $p<0.01$, *** $p<0.001$, **** $p<0.0001$

Table 2. Mean values and standard deviations (SD) of session synchronies ESnoabs-all of each session, for electrodermal activity (EDA) and respiration (RESP)

session-ID	**EDA**	**RESP**
J001_2	94.49* (SD=86.49)	0.82 (SD=8.37)
J001_7	41.83* (SD=8.95)	6.15 (SD=8.95)
J001_16	59.71* (SD=43.97)	–8.06 (SD=18.82)
J002_2	–2.10 (SD=51.56)	10.12 (SD=15.41)
J002_6	37.50 (SD=109.21)	6.99 (SD=11.57)
J003_2	46.85 (SD=109.51)	4.67 (SD=16.14)
J003_5	60.95* (SD=55.63)	3.74 (SD=6.87)
J004_2	68.00 (SD=109.03)	8.05 (SD=16.17)
J004_5	4.48 (SD=20.27)	–1.67 (SD=4.12)
J005_3	2.29 (SD=14.45)	6.56 (SD=13.66)
J005_6	31.67 (SD=40.34)	4.64 (SD=29.24)
J006_2	–9.51 (SD=4.37)	7.54** (SD=3.50)
J006_7	13.60 (SD=29.43)	–0.54 (SD=15.52)
J007_2	46.98 (SD=54.64)	1.37 (SD=7.68)
J008_2	1.20 (SD=12.32)	–5.27 (SD=7.74)
J008_5	–1.10 (SD=21.97)	–4.18 (SD=11.74)
J009_2	63.50 (SD=85.92)	8.08 (SD=11.32)
J009_6	–2.86 (SD=20.03)	–2.44 (SD=9.73)
J010_2	24.96 (SD=88.24)	0.23 (SD=14.64)
J011_2	55.21 (SD=61.97)	–5.12 (SD=19.92)
J012_2	7.00 (SD=16.17)	–1.10 (SD=14.02)
J012_6	7.66 (SD=46.91)	–2.46 (SD=8.99)

Note. Segment size=60s, maxlag= 5s. One-sample *t*-tests: * $p<0.05$, ** $p<0.01$

Table 3. Mean and standard deviation (SD) values of synchronies ESnoabs of reflection periods, for electrodermal activity (EDA) and respiration (RESP)

	EDA			**RESP**		
all dyads	*M*=1.58 (SD=3.65)	*t*(30)=2.41*	*t'*(30)=2.55*	*M*=0.16 (SD=0.85)	*t*(30)=1.06	*t'*(30)=1.27
C-C dyads	*M*=0.68 (SD=5.07)	*t*(30)=0.74	*t'*(30)=0.02	*M*= – 0.06 (SD=0.92)	*t*(30)= – 0.34	*t'*(30)=0.62
C-T dyads	*M*=1.53 (SD=3.49)	*t*(30)=2.44*	*t'*(30)=2.61*	*M*=0.32 (SD=1.08)	*t*(30)=1.63	*t'*(30)=2.19*
T-T dyads	*M*=2.71 (SD=7.95)	*t*(30)=1.90	*t'*(30)=2.40*	*M*= – 0.24 (SD=2.80)	*t*(30)= – 0.47	*t'*(30)= – 0.58

Note. Parameter setting for synchrony computation: Segment size=20s, maxlag= 5s
t=one-sample *t*-tests against zero: * $p<0.05$, ** $p<0.01$
t'=one-sample *t*-tests against zero, with synchronies ESnoabs weighted for the lengths of respective reflection periods: * $p<0.05$, ** $p<0.01$

Table 4. Process-outcome associations: Synchrony predicted by ORS (Outcome Rating Scale) measuring clients' well-being when entering the session. Results of regression models derived from 22 couple therapy sessions

Dependent Variable ESnoabs-C-C (EDA)	*n*=22
Independent Variable: ORS_C-SUM	*t*= –2.47*
Random effect: Therapy# (% variance)	11.9
Whole model r^2 (% variance)	43.9

Note. Outcome Rating Scale with averaged data of both clients' sum of all aspects of well-being (ORS_C-SUM). * $p < .05$

Table 5. Process-outcome associations: Synchrony predicted by SRS (Session Rating Scale), measuring alliance. Results of regression models derived from 20 to 22 couple therapy sessions

Dependent Variable ESnoabs-C-C (EDA)	*n*=20 [a]
Independent Variable: SRS_T-SUM	*t*= –2.32*
Random effect: Therapy# (% variance)	41.2
Whole model r^2 (% variance)	68.5

Note. Session Rating Scale only with averaged data of both clients (SRS_C-SUM) or therapists (SRS_T-SUM), respectively; all aspects of therapeutic relationship considered; [a]two sessions with missing therapists' SRS items. * $p < .05$

Table 6. ***Reflection Period 1:*** *Reflective conversation focused on both clients, spouses show agreement in their responses*

In the extract below, we show a reflection period from the last session of a couple therapy process consisting of altogether six sessions. In this reflection period, there is a clear structure in which the therapists first indicate that they will start their mutual talk, then they start addressing talk to each other, and after a couple of minutes of talk between the therapists, they again say that the reflective talk ends. After that, they turn to clients to ask their comments on what they heard. In the extract, we present a transcript of the discussion (Column 1), qualitative description of the interaction (Column 2) and the relevant physiological results (Column 3). Therapist 1 (T1) is female and Therapist 2 (T2) is male. The original Finnish transcription has been translated to English. The synchrony values are computed between lines 1 and 73. We however include in the extract also the discussion after that, to indicate what the clients' verbal and behavioural reaction to the reflection was. For the transcript notation, see the appendix.

Transcript of the Conversation	Description	EDA and RESP Synchrony
1 T1 Well let's discuss now (1) in our turn *((clients look at the therapists; seemingly attentive))* 2 T2 What did you hear today 3 T1 Hmmm ((sighs))(1) towards the end I was pleased to hear how safe atmosphere there has been in our joint discussions here (.) it is exciting (.) I hope also W has felt this (2) what I have noticed (.) and (2) *((H changes position, bends and looks down))* also that (.) during this year there have been a lot of changes *((H straightens his position and looks at the therapists))* ((60 lines omitted; in these lines, the therapists, addressing each other, evaluate in positive terms the change they have seen in clients' communication skills. On	During the therapists' reflective talk, the spouses withhold talk or other vocal activities, treating themselves as "overhearing audience" (Goffman 1981) but not active participants of the discussion. Yet, they are attentive, as indicated by them gazing at the therapists.	**- Client-client dyads:** In client-client dyads, no high positive values: low positive value in EDA (0.39), as well as in RESP (0.716) **- Client-therapist dyads:** In EDA high value (2.76) between W and T2 (male) t; smaller positive value (1.6) between H and T2 (male) negative values between W and T1 (female) (-4.75) and between H and T1 (female) (-2.19).

T2's initiative, the therapists also acknowledge how the spouses have been able to share parenthood for the H's child from his earlier relationship.)) 67 T1 those (.) most relevant *((H smiles))* 68 T2 yeah (.) now I do not have anything else *((smiles))* 69 T1 hmm *((smiles))* 70 T2 to add (2) certainly there has been a lot more 71 T1 mmmh (3) 73 T2 ((quietly)) would you have something you would like to comment on this (2) 75 W Nothing else but thank you (.) that sounds good at least for now (.) that what you said *((H smiles))* and (.) what you had noticed about the parenthood issue (1) *((H gazes at W; W gazes at T1))* well you have quite right noticed (1) that it is really important for me (.) at least the social parenthood (.) *((W nodding))* and I don't know how much for [the child H [((makes some sound, not words, maybe a cough)) W also the psychological oh (1) somehow it is an important issue (.) and it is also important that (H) *((gazes H))* has given this space ((for taking the parenting role*)) ((W touches her hair; H looks down and then at W))* T1 hmm	After the therapists have collaboratively brought into conclusion their reflections (see lines 67-71), T2 offers the clients an opportunity to give their comments (line 73). The wife takes the turn. She first gives her thanks and expresses appreciation on the reflective talk as a whole (lines 75) and then points her focus on one issue, i.e. "parenting". She first confirms the therapists' notion that what she names as "social parenting" is important for her (line 77) and then moves on to present her own further reflections on parenting (lines 77-84) . The therapists receive her talk with acknowledgement tokens (lines 81,85,86). After the therapists' acknowledgments the female client utters "hmm" (line 87) and then turns to her husband to ask about his view. Husband, smilingly, says that he has nothing to add. All in all, the clients' reaction to the therapists' reflection seems to convey appreciation, agreement, and affiliation. Although wife is more	In RESP Very high value (6.34) between W and T2 (male), lower positive value (0.94) between W and T1 (female). Negative value (-1.2) between H and T1 (female), low positive value (0.53) between H and T2 (male). **- Therapist-therapist dyads:** In EDA, negative value (-1.21) In RESP high positive value in (1,65).

W and then maybe also the (.) the so that (.) like in the middle of all the conflicts ((the boy)) *((W touches her hair; therapists nodding))* and all the issues related with child rearing (.) is actually the issue of which we have never had any quarrels (1) and this is a big thing 85 T1 mmh (2) yes T2 okay W hmm would you like to say something *((turns to H))* H I don't have anything (1)((gazes W, then turns to the therapists)) to add ((smiles))	active in talk, the husband seemingly shares this stance.	

In Extract 1, W displays actively affiliation and agreement after the reflective discussion. Seemingly, this corresponds with the relatively high synchrony values in EDA between her and the therapists. In female therapist (T1), the value is however negative, indicating anti-phase synchrony. In respiration, W and male therapist (T2) were in high synchrony. The high positive synchrony values between W and male therapist (T2) might be associated to the fact that it was T2 who brought the topic of parenthood into the reflective discussion; in her comments, W showed her appreciation of this. The male client was less active in displays of affiliation, which seemingly corresponds to his lower synchrony values with the therapists.

Table 7. ***Reflection Period 2:*** *Reflective conversation more focused on one client's perspective, spouses' responses differ*

The other reflection period shown below is from the second session of the couple therapy process consisting of four sessions altogether. The Reflective period is in the middle of the session, starting about 45 minutes after the session start. The length of the reflective period is two minutes, and it focuses mainly on the female client. The synchronies were calculated for the two-minute period. Here, we will only show the end of the therapists' reflective talk (lines 1-9), and the rest of the transcript shows how the clients' responses to it differ from each other. Both therapists (T1 and T2) are male.

Transcript of the Conversation	Description	EDA and RESP Synchrony
01 T1: all this-this and I think what they are doing now they are negotiating on those issues 02 T2: but if I would be a mother *((H smiles, turns to look at T2)*) in a situation in which I realize that I cannot take care of everything *((H changes position, stops smiling))* because the baby is not sleeping and I feel myself very depressed (.) and then there is another one (.) the father taking care (.) that would mean that I could feel my myself even worse (.) in the situation because even if I have a good husband *((H smiles))* so-so I-I cannot manage those take care of this *((W nods))* so I think they are very many deep (.) questions all the time 08 T1: yea yea of course they are evoking feelings 09 T2: yes yea yea *((turns to look at the clients, nodding))* (3) 10 T2: mm 11 W: yea *((glances briefly at H))* (8) 13 H: i-i-it's *((smiles, touches his neck; W smiles, turns to gaze at H; T1 bites his lip))* 14 T2: yea	After T2 has discussed the wife's emotions in a hypothetical scenario ("If I would be a mother...", line 02), T1 comments on the scenario (line 08) and T2 produces acknowledgement tokens (lines 9 and 10) which may signal that T2 is ready to close the reflection. He also turns to the clients, indicating an expectation that they would take the turn. W -- whom the reflective commentary focussed on -- produces her acknowledgment token (line 11) which also may convey an understanding of the closure of the	**-Client-client dyads:** In EDA negative value (-1.136) In RESP, low positive values (0,24). **-Client-therapist dyads:** In EDA, high positive values between W and T1 (1,27), between W and T2 (0,82) and between H and T1 (0.76). Negative value (-1.1) between H and T2 In RESP Most values close to zero, only between W and T1 negative value (-0.95) and between W and T2 low positive value (0.52). **Therapist-therapist dyads:** In EDA, negative value (-1.38). In RESP, low value (0.23)

15 H: I-I'm struck ((*touches his neck and head, looks up smiling, keeps hand on his forehead; W smiles and drinks water*)) by this conversation in some ways in terms of it's (2) I think about we came in here ((*making a wave-like hand movement with his palm facing to W, illustrating "we" and "here"*)) I guess to talk about us 17 T2: mm hm 18 H: yet most of our conversations hasn't been about us (.) it's about (1) ourselves and our relationship with Eva *((looks at the therapists))* 20 T2: yes 21 H: and (.) yea that's interesting *((turns to look at W, smiles; W smiles back, looks at H; T4 smiles))* 22 W: it's interesting (.) but that's what's impacted our relationship *((H stops smiling))* 23 H: yea (2*) ((moves his head sideways, looks at W; W stops smiling; T2 smiles))*	reflection. A silence of 8 seconds ensues, whereafter the husband in line 13 takes a turn yet aborting his speech. T2 adds yet another acknowledgment token (line 14) which may convey that he is not intending to talk further. Thereafter the husband starts a commentary where he points out that the therapeutic talk has not been what he expected (lines 15-22). His comment is "prompted" by the reflection, although what he says is more related to the topics of the entire session, and not to what the therapists said in their reflection. It is also possible that the therapists' way of focusing on the wife's experiences in their reflection might have prompted the husband's critical stance; yet he does not directly indicate that. In line 22, the wife takes the turn to respond to her husband, indicating disagreement with his view, and displaying more positive evaluation of the focus of the therapy.	

Overall, the sychnrony values between the clients and the therapists in Exract 2 are lower than Extract 1. Seemingly, this corresponds to the clients' non-affiliative response to the reflection. The disagreement between the spouses might also have affected the synchronies between the participants.

Transcript Notation

Symbol	Meaning
yes (1) me too	**Figures in rounded brackets represent inter- and mid-turn silences, hand-timed in seconds.**
yes (.) me too	**The period in rounded brackets represents "micro-pauses" of less than 0.2 seconds.**
((wiping tears))	**Double rounded brackets contain relevant contextual and nonverbal information added by the transcribers.**
I-I thi- I think so	**A single dash following a word or letter(s) indicates an abrupt cutoff in the flow of speech (stammering).**
[and well on the whole **[oh yes]**	**Overlapping utterances are marked by single square brackets.**