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Synchrony in psychotherapy: High physiological positive concordance predicts symptom reduction and negative concordance predicts symptom aggravation

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Abstract

Objective: Therapeutic alliance is often considered as a predictor for therapeutic success. This study explored dyadic synchrony of skin conductance response (SCR) during naturalistic therapeutic interactions and investigated its potential as an objective biomarker for predicting therapy effectiveness.

Methods: In this proof-of-concept study, skin conductance from both dyad members was continuously measured via wristbands during psychotherapy. Patients and therapists completed post-session reports capturing their subjective appraisal of therapeutic alliance. Additionally, patients completed symptom questionnaires. Each therapeutic dyad was recorded twice in a follow-up design. The first session of the follow-up group was assessed for physiological synchrony (Single Session Index (SSI)). Therapy outcome was captured by the difference between symptom severity scores over time.

Results: SCR synchrony significantly predicted the outcome variable of change in patients' global severity index (GSI). High positive SCR concordance was linked to a reduction in patients' GSI, while negative or small positive SSI values were linked to an increase in patients' GSI.

Conclusion: The results demonstrate the presence of SCR synchrony in clinical interactions. Skin conductance response synchrony was a significant predictor for change in patients' symptom severity index, emphasizing its potential as an objective biomarker in the context of evidence-based psychotherapy.

KEYWORDS
cognitive behavioural therapy, interpersonal synchrony, objective biomarkers, psychotherapy research, skin conductance

1 | INTRODUCTION

The psychotherapeutic alliance has been studied extensively over the last century. Initially, it was described as a concept of transference and countertransference (Freud, 1913). Later, Rogers defined three core components in the therapeutic relationship: empathy, unconditional positive regard, and congruence (Rogers, 1951). Given that 'alliance' is inherently dynamic (Luborsky, 1976), the definition of therapeutic alliance evolved into a *pantheoretical concept* (Horvath & Luborsky, 1993). Bordin assumed that a positive alliance is not itself curative, but rather it is the fundament for patients' acceptance and process in therapy, leading to interdependence (Bordin, 1989). In the current study, therapeutic alliance is operationalized as a *collaborative and effective bond between therapist and patient* (Martin et al., 2000, p. 438). Evidence shows that the quality of therapeutic alliance can predict clinical outcome (Ardito & Rabellino, 2011) and therapeutic success (e.g., Bordin, 1979; Falkenström et al., 2013; Horvath et al., 2011). Typically, therapeutic alliance is quantified subjectively by therapists, patients or external raters using various questionnaires and self-rating scores. This lends to inconsistency and potential biases related to response style, halo-effects (Podsakoff et al., 2003), and psychological factors, such as cognition or social desirability (Bertrand & Mullainathan, 2001). Thus, the quest for more reliable and objective biomarkers for predicting therapeutic effects is warranted.

Given the dyadic setting in individual psychotherapy, interpersonal coordination appears as an innate phenomenon of time-dependent covariation between interactants (Butner et al., 2014). In previous studies, interpersonal coordination, also termed *interpersonal synchrony* (IPS), showed associations with rapport (Miles et al., 2009; Vacharkulksemsuk & Fredrickson, 2012), affiliation (Hove & Risen, 2009), and empathy (Imel et al., 2014; Marci et al., 2007; Reich et al., 2014). The potential of using IPS as an objectively measurable predictor in psychotherapy has been investigated through various modalities, including physiology (e.g., Karvonen, 2016; Kodama et al., 2018; Palumbo et al., 2017; Wiltshire et al., 2020), speech (Reich et al., 2014) and movement (Fujiwara et al., 2020; Ramseyer & Tschacher, 2011, 2016). *Interpersonal autonomic physiology* refers to the rhythmic and temporal coordination of physiological processes of the autonomic nervous system between people (Palumbo et al., 2017). Interpersonal autonomic physiology has been explored with different physiological variables, such as heart rate dynamics (Kodama et al., 2018; Tschacher & Meier, 2019), respiration (Tschacher & Meier, 2019), and Skin Conductance (SC) (Bar-Kalifa et al., 2019; Marci et al., 2007; Marci & Orr, 2006; Messina et al., 2013). Mostly, Interpersonal autonomic physiology has been linked with measures of emotion and empathy (Marci et al., 2007; Marci & Orr, 2006; Messina et al., 2013) and not directly to therapeutic outcome, such as reduction of symptom severity over time. Primarily, therapy effectiveness was explored by analysing movement synchrony, showing that stronger movement synchronization was associated with fewer symptoms and increased beneficial treatment outcomes, such as goal attainment (Ramseyer & Tschacher, 2016). Unfortunately, most studies evaluate IPS in individualized therapeutic settings within a single session (Wiltshire et al., 2020). However, therapeutic effectiveness, defined as symptom reduction over time, requires at least two sessions per dyad to comprehensively evaluate IPS in therapeutic interactions. Additionally, portable devices, like wearables, provide the opportunity to reduce environmental biases linked to a lab-based assessment when capturing naturalistic interactions.

Thus, this proof-of-concept study focussed on the interpersonal synchronization of skin conductance response (SCR) during psychotherapy. Skin conductance response synchrony was analysed as a potential predictor of therapy effectiveness for psychiatric patients in a follow-up assessment. The study aimed (i) to confirm that movement and physiological IPS emerges during cognitive behavioural therapy (CBT) sessions, and (ii) to examine whether physiological IPS or ratings of therapeutic alliance might predict symptom change in a follow-up assessment.

2 | MATERIALS AND METHODS

2.1 | Participants

In total, 25 patient-therapist dyads participated in the study. 19 dyads met twice as part of the follow-up assessment, while 6 dyads participated only once. Patients were recruited from the in- and outpatient departments of the Clinic for Psychiatry and Psychotherapy (Ludwig-Maximilians-University [LMU] Munich). Participants with cardiac disease or implants, acute substance abuse, high dose beta-blockers, acute neurological disorders or with severe skin defects that might affect physiological measurement were not included. All participants had normal or corrected-to-normal vision. For the physiological data, three of the 19 dyads from the follow-up group were excluded because of low signal quality in at least one of the dyads' members electrodermal activity (EDA) timeseries. *EDA Explorer* (Taylor et al., 2015), a free software tool, was used for detecting noise automatized within the EDA signal. The software's machine learning classifier accounts for temperature and acceleration data in addition to individuals' EDA data. A binary classifier was used to report 5-s epochs of EDA data as signal or noise. Dyads with more than 40% detected noise in at least one of the dyad members' time series were excluded from further analysis. For the follow-up assessment of symptom reduction, only dyads assessed twice and with complete questionnaires were analysed. Two dyads of the follow-up assessment group did not complete all questionnaires, leading to their exclusion. Thus, the follow-up group used for analysis included 14 dyads whose CBT sessions ($n = 28$) were at least two weeks apart. This was comprised of a mixed clinical patient sample ($N = 14$, 64.3% female, 35.7% male, $M_{age} = 38.8 \pm 15.5$). Each patient had at least one ($n = 11$) or several ($n = 3$) diagnoses of a mental disorder according to ICD-10, Chapter V(F) (World Health Organization, 1993). The follow-up group also included 10 different therapists ($N = 10$, 70.0% females, 30.0% males, $M_{age} = 33.9 \pm 7.6$) with four therapists participating with two of the patients. The full summary of demographic data can be found in Tables 1–3 (Suppl.).

Written informed consent was obtained from all participants and institutional review board approval was granted by the LMU Medical Faculty Ethics Board (19–170).

2.2 | Study design

Data collection took place in a designated therapy room at the Clinic for Psychiatry and Psychotherapy (LMU Munich). Patient and therapist sat at a 60-degree angle and were advised to stay seated in their chairs during the session. E4 wristbands (Empatica, Milan, Italy)—a non-invasive, research-grade multisensor - were used to continuously measure physiological data from both dyad members during the CBT session ($M_{duration}$ = 47 ± 1.8 min). Participants wore the wristband on their non-dominant arm and were encouraged to keep it still to minimise movement artefacts. Additionally, the interaction was filmed by a fixed video camera to assess the body and head movements during the interaction. Verbal behaviours were not analysed. Before the session, data was temporally aligned by a timestamp from the wristband. Afterwards, the dyad was left alone in the room for the entire session, and no instructions about spoken content were given. Following the session, both dyad members completed a post-session report, and patients also rated their somatic and psychological symptom burden. At least 2 weeks passed before the recording of the follow-up session took part.

2.3 | Materials

2.3.1 | Movement data

CBT sessions were filmed with a standard video camera and later analysed with *Motion Energy Analysis Version 3.10* (MEA; Ramseyer & Tschacher, 2011), a free software tool for quantifying movement IPS of the upper body and head. Motion Energy Analysis is a frame-differencing method that measures grayscale pixel changes in predefined regions of interest (ROI) (see Ramseyer, 2020 for more details). Videos were synchronized with physiological data by using the wristband's timestamp. The first 5 min of each session were discarded from analysis to allow dyads to adjust to the setup and reduce associated movement artefacts. The following 10 min were used to calculate movement IPS.

2.3.2 | Skin conductance

Skin Conductance was measured in micro-Siemens (μS) with a frequency of 4 Hz by the wristband (Empatica, Milan, Italy). *EDA Explorer* (Taylor et al., 2015) was applied to detect any noise in the SC time series (see Section 2.1). Skin Conductance time series were preprocessed using *Ledalab V3.4.9* (Benedek & Kaernbach, 2010), a Matlab-based software tool. A low-pass Butterworth filter with a cut-off frequency of 5 Hz was used to remove high-frequency noise induced by movement or irregular respiration (Schumm et al., 2008). Then, a continuous decomposition analysis (Benedek & Kaernbach, 2010) was applied, separating SC into Skin Conductance Response (SCR) and Skin Conductance Level (SCL) (Kyriakou et al., 2019; Schmidt & Walach, 2000). The SCR amplitude is an index of sympathetic activity (Benedek & Kaernbach, 2010). As with movement synchrony (see Section 2.3.1), the first 5 minutes of each session were excluded from analysis, and the subsequent 10 min were used to calculate SCR synchrony.

2.3.3 | Self-report questionnaires

Patients and therapists completed a specific post-session report (*BPSR-P 2000/BPSR-T 2000*; Flückiger et al., 2010), capturing patients' subjective ratings on eight subscales and therapists' ratings on 11 subscales. Items are scored on a seven-point scale, where higher scores reflect a more positive agreement to the question. Presently, *therapeutic alliance* was the subscale of interest. Patients' depressive symptoms were assessed with the German version of the *Beck Depression Inventory—Second Edition* (BDI-II; Hautzinger et al., 2009) after each session. Patients' symptom severity was also assessed using the self-rating *Brief Symptom Inventory* (BSI; Franke, 2000), which measures psychological distress and clinically relevant somatic symptoms experienced over the past 7 days on a four-point scale. The current analysis focussed on the variable *Global Severity Index* (GSI) and its change in the follow-up assessment (ΔGSI), indicating the change in severity of reported symptoms. For descriptive statistics see Tables 4–8 (Suppl.).

2.4 | Data analysis

Data pre-processing and analysis of interpersonal physiological and movement synchrony were conducted in *RStudio V1.1.463* (R Studio Team, 2020) using the statistical programing language *R V4.1.0* (R Core Team, 2021) and *Matlab R*2021b (The MathWorks, Inc., 2021). Movement IPS was computed using lagged windowed cross-correlations. Physiological synchrony of SCR was calculated by the *Single Session Index (SSI)* algorithm, which is commonly used to capture SC synchrony during interactions (Haataja et al., 2018; Karvonen, 2016; Marci et al., 2007).

2.4.1 | Movement synchrony

Dyads' head and body movement time series were cross correlated in moving windows of 60 s for all time lags between −5 and +5 s and with 60-s window increments using the *rMEA* package (Kleinbub & Ramseyer, 2021). Absolute cross-correlations for both ROIs were Fisher's Z-transformed and aggregated by calculating the grand mean, resulting in two movement IPS values per session (i.e., head and body synchrony). To evaluate whether the calculated movement

IPS values were above chance-level, time series between dyad members were shuffled to generate randomly matched dyads ($N = 50$). More precisely, each patient's movement time series was matched with a therapist's time series with which they have never interacted. Surrogate movement IPS values for both ROIs were also calculated for the pseudo-dyads.

2.4.2 | Physiological synchrony

A *Single Session Index* (*SSI*; Marci & Orr, 2006) was computed as an overall measure of synchrony for SCR per each dyad. This index captures concordance rates, meaning correlations of window-wise slopes. First, average slopes of individuals' SCR timeseries within a sliding 5-s window at 1-s increments were calculated. Second, Pearson correlations with lag-zero were calculated over sliding 15-s windows between both dyad members' time series of averaged slopes. Afterwards, a natural log transformation was applied to the ratio of the sum of positive correlations over the sum of negative correlations (Marci & Orr, 2006). Equal numbers of positive and negative correlations lead to a SSI value of zero, interpreted as *balanced concordance* (Marci & Orr, 2006). Consequently, a SSI value greater than zero reflects relatively more positive SCR concordance, while a negative SSI value reflects relatively more negative SCR concordance. An overview of the SSI descriptives can be found in Table 9 (Suppl.).

As for movement synchrony, SCR synchrony scores from original dyads were compared to randomly matched dyads. Original dyads were shuffled randomly in time and between participants, leading to pseudo-dyads. Pearson correlation matrices of SCR slopes were calculated for original and pseudo-dyads (i.e., the second step in the SSI calculation). All correlation values for original and pseudo-dyads were averaged by their absolute values.

2.4.3 | Statistical analysis

To test that the applied synchrony methods yielded valid movement and physiological IPS measurements, a Mann-Whitney *U* test was applied as a non-parametric test to examine the significance between original and pseudo-dyads' movement IPS rates, as the Shapiro-Wilk test showed a significant departure from normality for pseudo-dyads' movement IPS values ($W = 0.95$, $p < 0.05$). For SCR synchrony scores an independent *t*-test was applied, as both groups of dyads showed normally distributed values when applying a Shapiro-Wilk test ($p > 0.05$). The central research question was examined with a correlation matrix assessing whether IPS from the first session of the follow-up group was associated with individuals' post-session rating scores of therapeutic alliance. Moreover, a simple linear regression investigated whether physiological IPS from the first session of the follow-up group predicted patients' change in symptom severity (i.e., ΔBDI, ΔGSI).

3 | RESULTS

3.1 | Synchrony versus pseudo-synchrony

No significant effect was found in the body ROI, despite original dyads ($N = 14$, $M = 0.073$, SD = 0.022) attaining higher body movement IPS than pseudo-dyads ($N = 50$, $M = 0.071$, SD = 0.015), $U = 348.5$, $p > 0.05$. Head movement IPS from original dyads ($N = 14$, $M = 0.070$, SD = 0.01) was significantly higher than for pseudo dyads ($N = 50$, $M = 0.062$, SD = 0.011), $U = 498.5$, $p = 0.016$, one-tailed, $r_{rb} = 0.424$. The independent *t*-test showed SCR synchrony from original dyads ($N = 14$, $M = 0.300$, SD = 0.038) to significantly exceed pseudo-synchrony values ($N = 14$, $M = 0.219$, SD = 0.033), $t(26) = -6.015$, $p < 0.001$. Thus, body movement IPS was excluded from further analysis.

3.2 | Movement synchrony and therapeutic alliance

Head movement IPS, measured in the first session of the follow-up group, showed a significant negative association with patients' post-session rating scores of therapeutic alliance $r(12) = -0.702$, $p = 0.005$, which remained significant after applying Bonferroni correction.

3.3 | Prediction of symptom change

Head movement IPS did not show any significant association with patients' change in symptom intensity over time. Patients' ratings of therapeutic alliance showed a positive association with the follow-up variable ΔBDI, *rho* (12) = 0.643, $p = 0.013$, which remained significant after applying Bonferroni correction ($p_B = 0.025$). Visual inspection showed that the association was not linear, resulting in a non-significant simple linear regression model when using patients' ratings of therapeutic alliance as a predictor of ΔBDI ($p > 0.05$). An overview of correlations between objective and subjective variables can be found in Table 10-11 (Suppl.).

Skin conductance response synchrony significantly predicted ΔGSI ($R^2 = 0.429$, $F(1,12) = 9.009$, $p = 0.011$), also after applying Bonferroni correction ($p_B = 0.025$). The linear regression model fulfiled all needed statistical requirements: independence of errors and homoscedasticity. The fitted regression model was (see Figure 1): $\Delta GSI = -0.12234 + 1.06878*(SSI)$.

Referring to the fitted regression term, SSI values greater than 0.11 were linked to a reduction of patients' GSI ($\Delta GSI > 0$), while negative SSI values and small positive SSI values ($SSI < 0.11$) were linked to an increase of patients' GSI ($\Delta GSI < 0$) over time. To test whether descriptive variables, such as age difference between dyad members, sex of patient or therapist, or gender difference between interactants, influence the linear regression model, each variable was separately included as a predictor variable, in addition to the SCR

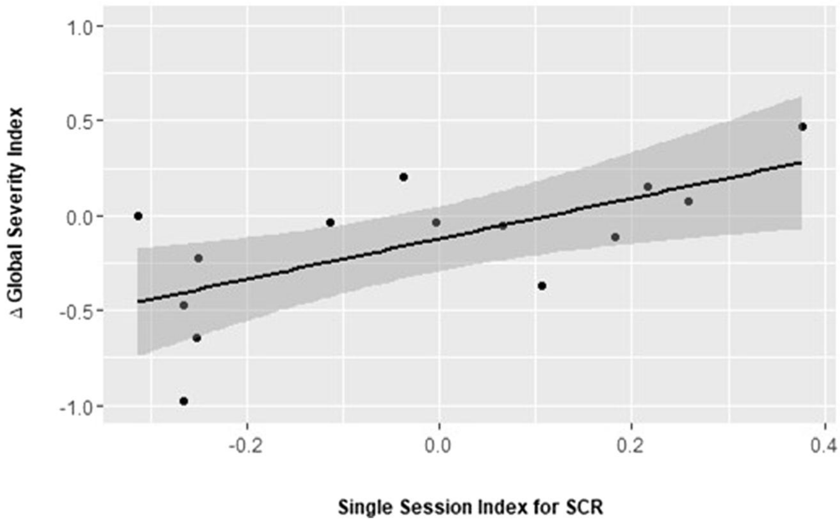

FIGURE 1 Prediction of Change in Patients' global severity index (GSI) by Synchrony in Skin Conductance Response (SCR). *Note*. Prediction of change in patients' ratings of their GSI (ΔGSI) displayed by a simple linear regression model with the objective independent variable synchrony in SC Response (SCR) including linear trendline and confidence interval (dark grey). Positive Δ GSI values represent a reduction of patients' GSI, while negative values stand for an increase over time. A value of zero reflects no change between patients' ratings of their GSI over time. The Single Session Index (SSI) is an overall measure of synchrony, where a value of zero reflects balanced concordance (i.e., equal number of positive to negative correlations), while SSI values greater than zero reflect more positive concordance and vice versa. 43% of variance of the variable ΔGSI got explained by the objective predictor. The fitted regression model term is: $\Delta GSI = -0.12234 + 1.06878*(SSI)$.

synchrony score, for predicting ΔGSI (see Table 12, Suppl.). Due to the small sample size, it was not possible to include all variables in a multivariate model. All four regression models, each one with a different descriptive variable in addition to SCR synchrony as a predictor, met the criterion of significance and showed a robust estimate for SCR synchrony as a predictor for ΔGSI (see Table 1).

4 | DISCUSSION

Evidence highlights the therapeutic alliance as an important factor for success in psychotherapy (Horvath et al., 2011). Yet, it has mainly been assessed in a purely subjective manner thus far. Interpersonal synchrony has been associated with affiliation and rapport (Hove & Risen, 2009; Tickle-Degnen & Rosenthal, 1990) and may serve as an objective index for interpersonal affiliation. Thus, the focus of the current study was twofold: (i) to investigate whether IPS emerges during psychotherapy and, (ii) to investigate whether the objective measurement of SCR synchrony can be used as a predictor for therapy effectiveness—as indicated by a change in symptom burden in a follow-up assessment.

In the current study, head movement IPS showed a significant negative correlation with patients' ratings of therapeutic alliance. A linear regression model using head movement IPS as a predictor of therapy outcome was not significant. Both findings regarding movement IPS are in contrast with previous findings (Ramseyer & Tschacher, 2016). Nevertheless, similar results were reported in a study analysing movement synchrony in psychotherapy sessions with patients with borderline personality disorder (Zimmermann et al., 2021). The study reported a negative correlation between movement synchrony and subjective ratings of perceived goodness of the session (Zimmermann et al., 2021).

Our results serve as proof-of-concept showing SCR synchrony in our recorded CBT sessions, emphasizing that coupling of dyad members' autonomous nervous systems was part of the therapeutic process. The noted differences between original versus pseudo dyadic synchrony values are in line with several other studies, reporting the presence of SC synchrony (Marci et al., 2007; Marci & Orr, 2006; Messina et al., 2013). We found that SCR synchrony, assessed in the first session of the follow-up group, significantly predicted the outcome variable ΔGSI. Higher positive SCR concordance rates were linked to a reduction of patients' GSI, while negative and very low positive SCR concordance rates were associated with an increase of the GSI in the follow-up group. The effect of SCR synchrony on ΔGSI explained 42.9% of its variance, while subjective ratings of therapeutic alliance did not meet statistical significance in any prediction model. Our results underline the importance and further need to investigate physiological synchrony in therapy as an objective biomarker for treatment effectiveness.

Several limitations must be considered. Set-up and analysis of the current proof-of-concept study need to be confirmed in a larger sample size, where a multivariate model can be applied to test for interaction and confounding effects. Nevertheless, several confounding variables were separately entered with SCR synchrony as additional predictor variables for predicting ΔGSI. These models showed robust and significant predictions of SCR synchrony, irrespective of potential confounders (see Table 1). Compared to stationary devices, wearable devices are often more sensitive to motion

TABLE 1 Statistics for regression models.

	Model 1			Model 2			Model 3			Model 4			Model 5		
Predictors	**Estimates**	**SE**	***p***	**Estimates**	**SE**	***p***	**Estimates**	**SE**	***p***	**Estimates**	**SE**	***p***	**Estimates**	**SE**	***p***
(Intercept)	−0.122	0.079	0.146	−0.179	0.139	0.223	−0.121	0.137	0.396	−0.195	0.107	0.097	0.084	0.127	0.522
SCR SSI	1.069	0.356	**0.011****	1.135	0.390	**0.014****	1.068	0.377	**0.016****	0.963	0.372	**0.025***	0.992	0.323	**0.011****
Patient's age				0.091	0.179	0.623									
Therapist's age							−0.002	0.173	0.992						
Age difference										0.164	0.165	0.341			
Sex difference													−0.012	0.006	0.077
Observations	14			14			14			14			14		
R^2	0.429			0.441			0.429			0.476			0.576		
R^2 adjusted	0.381			0.340			0.325			0.381			0.499		
F-statistic	9.009		**0.011****	4.353		**0.041***	4.129		**0.046***	4.995		**0.029***	7.463		**0.009****

Note: Statistics for all 5 regression models (see Table 12, Suppl.) are reported, by Estimates, Standard Errors (*SE*), *p*-values (*p*), R^2 (adjusted) and the *F*-statistic. Dyads' skin conductance response (SCR) synchrony index (SSI) is used as a fixed predictor for all 5 models. Bold values and asterisks indicate statistically significant results against the threshold as follows: $^{*}p < 0.05$, $^{**}p < 0.025$.

artefacts. Our study set-up included motion tracking and synchronization of data sets, which allowed us to control for motion artefacts and exclude data sets that did not meet sufficient data quality requirements. Although some dyads were excluded, using wearables is largely beneficial instead of standard lab-based devices because they allow for capturing naturalistic interaction. Another limitation of the current study is the inclusion of a heterogeneous patient group. Group-wise comparison of patients with different psychiatric diagnoses should be explored in a larger sample size in future studies. For this proof-of-concept study, we aimed at a representative clinical sample treated with CBT. In our follow-up group more than half of the patients had at least one diagnosis out of the spectrum of affective disorders, coded in section F3 of the ICD-10 (World Health Organization, 1993). Notably, our study is representative of patients typically seen in treatment centres and shows that, despite diagnostic heterogeneity, there is high potential of SCR synchrony for symptom change prediction in psychotherapy. Moreover, we did not analyse speech or content, which may impact synchrony fluctuation between dyads. In line with our aim to capture naturalistic behaviour, we wanted to lower the threshold for patients taking part in a recorded CBT study knowing that spoken content in the field of acute psychotherapy is often very intimate. Finally, synchrony, in terms of SC dynamics, can be seen as a more objective parameter in comparison to other dyadic synchrony measurements, like movement synchrony. Interpersonal physiological attunement is not directly observable. Every person has their own varying SC baseline and range due to each individual's underlying condition and determinants. Therefore, SCR synchrony scores represent dyad members' attunement of activation and relaxation dynamics of their autonomous nervous systems.

Several synchrony algorithms exist, that differently capture the construct of synchrony (Kleinbub et al., 2020). There is a need in the field of comparative methods studies defining best practice of synchrony analysis methods for different contexts and settings (Altmann et al., 2022). Concerning the choice of algorithm, various parameters need to be considered, above all the input variable (i.e., speech, physiological, or movement data) and sampling rate, but also data quality, study set-up, or recording device (i.e., wearable or lab-based device). Considering our two input variables and different sampling rates, we opted for the most common analysis algorithms for motion and SC, respectively. For calculating movement synchrony indices, we used the method of aggregating absolute windowed cross-correlations (*rMEA*; Kleinbub & Ramseyer, 2021), leading to the limitation that those indices might be biased by negative cross-correlation values, also interpreted as 'anti-phase synchrony'. In contrast, using concordance rates (SSI; Marci et al., 2007) to quantify synchrony is quite common for the input parameter of SC.

These aggregated indices do not capture the complexity of alternating cycles of synchrony, that is, the micro-structure of "match-mismatch cycles", also described as "shift between rupture and repair" (Feldmann, 2020, p. 139). For Feldmann, it is precisely this flexibility and dynamic in the mother-infant synchrony behaviour that is central to promoting resilience (Feldmann, 2020). Hypersynchrony, but also a lack of synchrony are reported to result in regulatory difficulties in infants (Beebe & Lachmann, 2017; Granat et al., 2017). Future studies should explore the transferability of those findings from mother-infant research to the field of psychotherapy research. In particular, the effect of alternating synchrony between interaction partners should be investigated. Furthermore, the question should be addressed to what extent synchrony levels of different input parameters can be made comparable if different specific algorithms are required.

5 | CONCLUSION

The current study investigated objective biomarkers for indexing therapeutic alliance in the setting of real CBT sessions and predicting symptom reduction by capturing non-invasive measures of physiological behaviours. Skin conductance response synchrony during a CBT session was a strong predictor for change in patients' GSI over time. Our results demonstrate the potential for further research in the field, using wearables in the context of evidence-based psychotherapy. Applying psychophysiological interactional synchrony and machine learning algorithms to a larger sample for predicting symptom reduction in patients could personalize treatment choices and optimize patient-therapist matching in the future.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

ETHICS STATEMENT

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

DATA AVAILABILITY STATEMENT

The participants of this study did not give written consent for their data to be shared publicly, so due to the sensitive nature of the research supporting data is not available.

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