Using dual-EEG to explore therapist-client interpersonal neural synchrony

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Author contribution statement

TL and VL designed the study, writing the first draft of the paper. FG contributed to the review of the literature on the therapeutic relationship and the role of mindfulness practice. TL and KDS collected the data and pre-processed them; TL and VL analyzed the data. VL supervised the EEG data collection, pre-processing and analysis. All the authors reviewed the final version of the paper.

Keywords

dual-EEG, hyperscanning, brain synchrony, Therapeutic Alliance, attunement, Online therapy, therapeutic presence, mindfulness

Abstract

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The therapeutic alliance represents an important variable in explaining the outcome of mental health treatment. In particular, research suggests that mindfulness practice might help therapists to develop skills that are key to a good therapeutic alliance. Although the therapeutic alliance is well-recognised from a clinical perspective, basic quantitative research is still lacking about the neurocognitive mechanisms involved in establishing and maintaining the alliance between individuals. Recent advances in two-person neuroscience research have demonstrated that interpersonal neural synchrony -which may develop between speaker and listener, or parent and child -is a strong predictor of mutual understanding as well as social learning and influence. Further, social cues that improve communication quality and clarify intent effectively modulate levels of interpersonal neural synchrony, suggesting that this neural index is sensitive to dynamic changes in speaker-listener engagement. Given that the therapeutic alliance depends strongly on shared intentionality and mutual engagement between therapist and client, interpersonal neural synchrony may also index the quality and strength of the therapist-client alliance, and predict treatment outcome. If so, this quantitative neural index could provide a useful clinical tool for measuring and understanding the nature and efficacy of the therapeutic alliance. The present paper discusses these hypotheses, presenting preliminary data from a pilot study investigating neural synchrony between clients and therapists in face-to-face and videoconference interactions, comparing therapists who practice mindfulness with therapists without any mindfulness experience.

Contribution to the field

The therapeutic alliance represents an important variable in explaining the outcome of mental health treatment. Although the therapeutic alliance is well-recognised from a clinical perspective, basic quantitative research is still lacking about the neurocognitive mechanisms involved in establishing and maintaining the alliance between individuals. Recent advances in two-person neuroscience research have demonstrated that interpersonal neural synchrony - which may develop between speaker and listener, or parent and child - is a strong predictor of mutual understanding as well as social learning and influence. Further, social cues that improve communication quality and clarify intent effectively modulate levels of interpersonal neural synchrony, suggesting that this neural index is sensitive to dynamic changes in speaker-listener engagement. Given that the therapeutic alliance depends strongly on shared intentionality and mutual engagement between therapist and client, interpersonal neural synchrony may also index the quality and strength of the therapist-client alliance, and predict treatment outcome. If so, this quantitative neural index could provide a useful clinical tool for measuring and understanding the nature and efficacy of the therapeutic alliance. To our knowledge, this is the first study that used dual-EEG to document brain responses of therapists and clients, thus representing a first step towards understanding the neural mechanisms that support successful therapeutic interactions.

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In review

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Keywords: dual-EEG, hyperscanning, brain synchrony, therapeutic alliance, attunement, online therapy, therapeutic presence, mindfulness

Abstract

The therapeutic alliance represents an important variable in explaining the outcome of mental health treatment. In particular, research suggests that mindfulness practice might help therapists to develop skills that are key to a good therapeutic alliance. Although the therapeutic alliance is well-recognised from a clinical perspective, basic quantitative research is still lacking about the neurocognitive mechanisms involved in establishing and maintaining the alliance between individuals. Recent advances in two-person neuroscience research have demonstrated that interpersonal neural synchrony – which may develop between speaker and listener, or parent and child – is a strong predictor of mutual understanding as well as social learning and influence. Further, social cues that improve communication quality and clarify intent effectively modulate levels of interpersonal neural synchrony, suggesting that this neural index is sensitive to dynamic changes in speaker-listener engagement. Given that the therapeutic alliance depends strongly on shared intentionality and mutual engagement between therapist and client, interpersonal neural synchrony may also index the quality and strength of the therapist-client alliance, and predict treatment outcome. If so, this quantitative neural index could provide a useful clinical tool for measuring and understanding the nature and efficacy of the therapeutic alliance. The present paper discusses these hypotheses, presenting preliminary data from a pilot study investigating neural synchrony between clients and therapists in face-to-face and videoconference interactions, comparing therapists who practice mindfulness with therapists without any mindfulness experience.

1 INTRODUCTION

1.1 The therapeutic alliance and interpersonal synchrony

The therapeutic alliance is the most studied amongst the common factors, i.e. factors that are present in virtually all forms of psychotherapy, and, as outcome research has consistently shown, it plays a critical role within the psychotherapeutic process [1]. According to Bordin [2], it consists of three elements: agreement on the goals of treatment, agreement on the tasks, and the development of a personal bond characterized by mutual positive feelings. Meta-analyses of studies on treatments for both adults [3,4] and young people [5,6] have repeatedly shown an association between measures of therapeutic alliance and outcome, especially when alliance is assessed in the first stages of treatment [7]. Both clinicians [8] and clients [9] describe the therapeutic relationship as a key factor influencing the efficacy of the intervention; moreover, the quality of the client-therapist alliance is a reliable predictor of positive clinical outcome independent of the variety of treatment modalities and outcome measures [10].

Although the therapeutic alliance is well-recognized from a clinical perspective, basic quantitative research is still lacking about the neurocognitive mechanisms involved in establishing and maintaining the alliance between individuals. According to the Interpersonal Synchrony (In-Sync) model developed by Koole and Tschacher [11], the therapeutic alliance emerges from the coupling of client and therapist's brains, which can be achieved through the mutual coordination of their behaviors and experiences, made possible by synchronous activities (i.e. behavioral synchrony). This suggests that synchrony may be crucial in establishing the therapeutic alliance, however, the relationship between neural synchrony and the therapeutic alliance has not yet been empirically tested.

1.2 Affective attunement, mindfulness and therapeutic presence

Going beyond behavioral co-ordination, an effective therapeutic relationship also requires *emotional* engagement between therapist and client. Affective attunement has been described as “the performance of behaviors that express the quality of feeling of a shared affect state without imitating the exact behavioral expression of the inner state” [12]. It is an embodied experience that mostly happens below consciousness, emerging in the “present moment” [13]. The concept of embodied attunement has been developed by infant researchers, who studied the nonverbal communication between child and caregiver, characterized by behavioral aspects that “carry important relational information and are regulated in mutual interaction, within which the various attributes, including prosodic elements of speech, are turned into forms of feeling” [14]. This continuous process of emotional interchange, which constitutes the affective core of intersubjectivity [12], operates across different perceptual and expressive modalities, making it possible to share inner feeling states. The role of attunement in the therapeutic relationship has been studied by different authors, who mainly focused on nonverbal synchrony, finding that client's and therapist's bodily behaviors become synchronized during therapy sessions, as shown by coupled patterns in vocal pitch [15], matching levels of skin conductance [16], head movements [17], and whole body movements [17,18].

Affective attunement is rooted in the therapist's ability to be fully present and receptive, noticing the client's experience and responding to it accordingly. Therapeutic presence has been defined as having three components: “an availability and openness to all aspects of the client's experience, openness to one's own experience in being with the client, and the capacity to respond to the client from this experience” [19]. In particular, *mindfulness*, conceptualized as “awareness that emerges through paying attention on purpose, in the present moment, and nonjudgmentally to the unfolding of experience moment by moment” [20], has been explored as one of the few practices that can

concretely cultivate therapeutic presence [21,22]. Interestingly, some authors suggest that therapeutic presence represents the key to an effective therapeutic alliance [19,23]. As highlighted by Surrey [24], “psychotherapy requires mental presence; treatment cannot occur among passive participants. In this sense, some degree of mindfulness by the patient and the therapist is present in any effective therapy. Mindfulness practice is learning to become *more* present, and relational psychotherapy may be understood as a process whereby both the therapist and patient are working with the intention to deepen awareness of the present relational experience, with acceptance. While the therapist may be the only person in the room to carry this intention at first, over time, the therapist and patient discover healing together in shared moments of mindfulness”. This suggests that therapeutic presence may foster a good therapeutic alliance through affective attunement, and that, in turn, cultivating mindfulness may foster therapeutic presence.

In this context, videoconference therapy (i.e. virtual rather than physical presence) represents an interesting format to study the therapeutic relationship, as therapist and client can only see each other’s upper bodies and their perception of subtle nonverbal modulations is limited. A recent systematic review on videoconference therapy identified seven RCTs, three case-controlled studies and several uncontrolled pilot or single case studies that measured the therapeutic alliance, finding that patient-rated alliance in videoconferencing therapies was homogeneously high and equivalent to face-to-face therapies [25]. Even though only few studies have been conducted so far, these findings suggest that therapist and client are able to establish a good alliance also when nonverbal cues are limited, therefore videoconference therapies might offer an opportunity to determine what supports the therapeutic alliance and whether interpersonal neural synchrony can be hindered when two people are interacting remotely.

1.3 Interpersonal neural synchrony and the therapeutic relationship

Recent advances in two-person neuroscience research have demonstrated that interpersonal neural synchrony – which may develop between speaker and listener, or parent and child – is a strong predictor of mutual understanding [26–28] as well as social learning and influence [29]. Further, social cues that improve communication quality and clarify intent – such as eye contact – effectively modulate levels of interpersonal neural synchrony [28,29], suggesting that this neural index is sensitive to dynamic changes in speaker-listener engagement. Given that the therapeutic alliance depends strongly on shared intentionality and mutual engagement between therapist and client, it seems reasonable to expect that interpersonal neural synchrony may also index the quality and strength of the therapist-client alliance.

Further, it has been suggested that through the functioning of the mirror neuron system “the observation of another triggers an automatic and unconscious ‘embodied simulation’ of that other’s actions, intentions, emotions, and sensations. Embodied simulation [...] constitutes a fundamental functional mechanism for empathy and, more generally, for understanding another’s mind” [30]. The implications of this perspective for psychoanalysis have been discussed by Gallese and colleagues [30], who proposed “a mechanism in which the therapist’s accurately attuned response to the patient is automatically simulated by the patient, enhances the patient’s sense of ‘we-ness’ (a sense of connectedness to the other), and thereby contributes to a feeling of self-integrity. The patient’s embodied simulation of the therapist’s [behaviorally- and emotionally-] attuned response has the potential to clarify and articulate the patient’s own feeling state and therefore can itself contribute to self-integrity”. Both client and therapist may be noticing and responding to subtle verbal or non-verbal cues from the other, and the perception of these cues may activate shared neural patterns. This process may occur repeatedly, in a circular and reciprocal manner [30], and might be reflected in patterns of interpersonal neural synchrony.

Therefore, we suggest that interpersonal neural synchrony originates from affective attunement [12] and shared mental states [31–33] between therapist and client, which may be promoted by therapeutic presence and mindfulness practice. The present paper will explore this hypothesis, and report preliminary data on the measurement of therapist-client interpersonal neural synchrony in the context of their therapeutic relationship.

2 A PILOT STUDY

2.1 Aims and Hypotheses

The present pilot study was designed as a proof of concept, to assess the feasibility of using dyadic brain imaging methods to interrogate the therapeutic relationship. It is a first step towards understanding the neural mechanisms that support successful therapist-client interactions, with a specific focus on therapists' mindfulness practice, both in face-to-face and online settings. Following previous successful naturalistic studies of dyadic interaction [28,29,34], we used **dual-electroencephalography (dual-EEG)** to concurrently capture the brain activity of therapists and clients during therapy sessions. We predicted that therapists with experience of mindfulness practice would show higher levels of neural synchrony with their clients than therapists who did not practice mindfulness. We also expected that there would be higher levels of neural synchrony established during face-to-face as compared to online interactions. Finally, we hypothesized that higher convergence between client and therapist's perceptions of the alliance would be associated with higher neural synchrony.

2.2 Methods

Participants

In total, 27 participants took part in the study (13 therapists and 14 clients), yielding 14 therapist-client dyads (1 therapist participated twice with two different clients). Ten dyads interacted face-to-face and 4 dyads interacted online. Therapists varied in their level of mindfulness practice: 7 therapists attended at least an 8-week mindfulness course and practiced regularly, 6 did not practice mindfulness. Therapists with and without mindfulness experience were pseudo-randomly allocated across online and face-to-face conditions, yielding 7 dyads with and 7 dyads without mindfulness experience (5 face-to-face and 2 online for mindful and non-mindful groups each).

For the face-to-face condition ($N = 10$ dyads), 9 therapists (1 male, 8 female) participated in the study. They were between 22 and 49 years of age ($M = 35.90$ years, $SD = 7.37$). Clients were 10 young adults (2 male, 8 female), between 21 and 26 years of age ($M = 22.80$, $SD = 1.75$). For the online condition ($N = 4$ dyads), 4 female therapists participated in the study. They were between 23 and 49 years of age ($M = 42$ years, $SD = 12.7$). Clients were 4 young female adults, between 21 and 26 years of age ($M = 23.5$, $SD = 2.1$).

Clients identified themselves as having experienced low mood and/or anxiety in the last fortnight. Individuals with mental health diagnoses and/or sensory processing difficulties and those taking psychiatric medication were excluded from participation. Ethical approval was granted by the Department of Psychology Ethics Committee at the University of Cambridge (Application No: PRE.2018.008).

Procedure

Dual-EEG (Mobita TMSi, see Fig. 1 for details) was used to measure neural synchrony within therapist-client dyads as part of a therapy session, which was either delivered face-to-face ($N = 10$ dyads) or online ($N = 4$ dyads). The face-to-face session was set-up in a room designed to simulate a therapeutic setting (see Fig. 1a), whereas two different rooms were used for the online interactions. For this second condition, participants were communicating through monitors connected by wires to two different cameras – the therapist was watching the monitor connected to the camera in the client's room and vice-versa. This set-up simulated an Internet videoconference session while avoiding potential delays in the videos/audios, which might have constituted a confounding variable. Therapists with mindfulness experience listened to an audio-recorded mindfulness practice before the session, whereas the other therapists listened to a relaxation exercise.

To reduce the effects of inter-individual variability, dual-EEG data were collected twice from each therapist-client dyad using a 5-minute resting state task, administered before and after a 20-25 minute therapy session respectively. During the resting state task participants were asked to sit silently together whilst avoiding movement, in order to minimize speech and movement artifacts. However, other non-verbal affective cues (such as eye gaze, arousal and postural changes) were still present between the dyad. The same procedure was followed in face-to-face and online conditions. Therapist-client neural synchrony was computed using the Phase-Locking Value (PLV) [35] in Theta and Alpha bands, and across frontal and central sites (see Fig. 1 for details).

Finally, after the therapy session, therapists and clients separately completed questionnaires on the therapeutic alliance (*Working Alliance Inventory* (WAI); [36]), which reflects Bordin's definition of alliance. Both therapist (WAI-T) and client (WAI-C) versions of the questionnaire comprise 36 items referring to 3 subscales: goal, task and bond. Higher scores indicate a stronger therapeutic alliance. Many items of the bond scale refer to the therapist's contributions to the personal relationship; moreover, the scale (both therapist and client versions) highly correlates with therapist's empathy [37].

2.3 Results

Effect of mindfulness training on therapist-client interpersonal neural synchrony. Overall, significantly higher therapist-client neural synchrony was observed for therapists with mindfulness experience ($N = 7$ dyads) than without mindfulness experience ($N = 7$ dyads; $F(1,11) = 8.30, p < .05, \eta_p^2 = .43$; see Fig. 1b left). There was no significant interaction between mindfulness group and electrode region of interest ($F(1,11) = .57, p = .47$) or frequency band ($F(1,11) = .02, p = .88$), suggesting that this effect was consistently observed across both frontal and central regions, in both Theta and Alpha frequencies.

Effect of interaction modality on therapist-client interpersonal neural synchrony. No significant main effect of interaction modality was observed ($F(1,11) = .01, p = .94$; see Fig. 1b right), and there were also no significant interactions between interaction modality and electrode region of interest ($F(1,11) = 1.51, p = .25$) or frequency band ($F(1,11) = .51, p = .49$), suggesting that client-therapist neural synchrony did not differ significantly between face-to-face and online modalities in either frequency band or scalp location.

Therapeutic alliance and therapist-client interpersonal neural synchrony. To assess the relationship between the therapeutic alliance and neural synchrony, we computed the difference between

therapists' and clients' overall WAI scores for each session (i.e. WAI-T – WAI-C). For Alpha PLV over the central region, we observed a significant negative correlation ($r = -.67$, $p < .01$), suggesting that a smaller difference between therapists' and clients' scores (i.e. higher convergence) was associated with higher neural synchrony. Further, dyads where the clients' ratings were very much higher than their therapists' had the highest synchrony scores (see Fig. 1c). There was also a trend toward a significant negative correlation for central Theta PLV scores ($r = -.49$, $p = .07$), but no significant correlation with PLV scores from the frontal region ($p > .11$ for both Alpha and Theta bands).

2.4 Discussion

This pilot study demonstrates the feasibility of applying dual-EEG measurement methods for the study of the therapeutic relationship. The results supported our hypothesis that mindfulness practice is associated with elevated therapist-client neural synchrony, but, surprisingly, we observed no difference for face-to-face and online interaction modalities. This lack of a significant modality effect is likely due to the small sample size, but if the result is confirmed with a larger sample, it could potentially suggest that online modalities (which also support contingent, dynamic exchange of social cues) also allow a good therapeutic relationship to be established.

Further, we observed a significant correlation between the similarity in therapists' and clients' perceived strength of the therapeutic alliance and interpersonal neural synchrony, which indicates that an agreement on the quality of the interaction might be reflected in therapist-client neural synchrony. Interestingly, our results also suggest that interpersonal neural synchrony was stronger when WAI-C scores were much higher than WAI-T scores, which could indicate that the client's response and perception of the working alliance is the primary driving factor for therapist-client synchrony. However, these preliminary results should be interpreted with caution, as research shows that the WAI is a valid and reliable measure when used after the third session [36].

3 RECOMMENDATIONS FOR FUTURE RESEARCH

3.1 Relating patterns of behavioral, physiological and neural synchrony

The Interpersonal Synchrony (In-Sync) model [11] underlines that movement/behavioral synchrony may help to establish inter-brain coupling, which is crucial to develop the alliance, but does not take into account the role of affective synchrony (attunement) and shared mental states. In a recent study exploring soft prosody and embodied attunement in therapeutic interactions, Kykry and colleagues [14] identified two different patterns of synchrony between clients and therapists. "The first pattern showed a kind of 'complementary synchrony', i.e. a mirroring tendency in the arousal of the client and the therapist, occurring during the active therapeutic processing. The second pattern showed what could be called 'matching synchrony', i.e. a simultaneous decreasing tendency in the arousal of all the participants during a silent moment of the interaction" [14]. The complementary synchrony pattern was related to the differing roles and tasks in some specific interactions, when they were engaged in different challenges in order to work together towards the same therapeutic goal. A focus on both matching and complementary synchrony would be crucial to study attunement [14], which is largely cross-modal and reflects the feeling state and not the behavior *per se* [12]. For example, in a study by Reich and colleagues [38] vocal pitch synchrony between therapist and client was negatively associated with the quality of their relationship and therapeutic outcomes, thus suggesting that complementary synchrony might have represented a better response to clients' distress. Also eye contact might facilitate or hinder affective attunement [39]; in fact, people interacting together direct

their gaze to express and regulate their internal states, but also to monitor how the other person feels [40,41]. Infant research has shown that vocal pitch and gaze modulate interpersonal neural synchrony [28], but it is still unclear whether these behavioral cues would play the same role within the therapeutic relationship. In order to better understand different patterns of neural synchrony future research should focus on analyzing therapeutic interactions, identifying behavioral, physiological and neural responses during crucial relational events, for example ruptures within the alliance and subsequent attempts to repair them [42].

3.2 Measuring therapeutic presence

In the present study we compared therapists who practice mindfulness vs. therapists without any mindfulness experience, assuming that the first group would be “more present” during the interactions. Future research could administer measures of therapeutic presence, like the Therapeutic Presence Inventory [43], in order to empirically test the hypothesis that mindfulness practice supports therapeutic presence, but also to distinguish between different degrees of presence.

3.3 Interpersonal motivational systems

Another interesting avenue would be to study motivational systems within the therapeutic relationship. According to an evolutionary-ethological approach [44], we share at least seven motivational systems with primates. These systems direct our goals in social interactions and can be identified through the use of coding systems, like the Assessment of Interpersonal Motivation in Transcripts [44], making it possible to study their correlation with therapist-client neural synchrony.

3.4 Insight Dialogue (interpersonal mindfulness) and therapeutic presence

Insight Dialogue is a form of relational mindfulness specifically developed [45] to increase awareness and attunement while in the midst of an interpersonal interaction. Future research may explore whether therapists who practice Insight Dialogue are able to show an even deeper quality of therapeutic presence and if cultivating a form of specifically relational mindfulness fosters affective attunement and therapeutic alliance, as well as test whether this may correlate with increased interpersonal neural synchrony.

4 CONCLUSION

To our knowledge, this is the first study that used dual-EEG to document brain responses of therapists and clients as a function of their interaction modality and therapists’ mindfulness practice. Our results suggest that therapeutic presence (which is developed by mindfulness) may facilitate affective attunement, which is reflected in interpersonal neural synchrony between therapists and clients. Accordingly, the dual-EEG method may be a useful tool for the study of therapist-client interactions and aspects of the therapeutic alliance.

Conflict of Interest

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Authors Contributions

TL and VL designed the study, writing the first draft of the paper. FG contributed to the review of the literature on the therapeutic relationship and the role of mindfulness practice. TL and KDS collected

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Figure 1a. Face-to-face setup showing dual-EEG acquisition from therapist and client who each wear EEG caps throughout the session.

Figure 1c. Correlation between therapist-client central alpha PLV scores and WAI therapist-client scoring similarity. $**p < .01$

Figure 1b. Mean therapist client PLV scores (averaged over electrode locations and frequency bands) as a function of therapists' Mindfulness training (left) and interaction modality (right). $*p < .05$

EEG was recorded simultaneously from the therapist and client using a 2 x 32-channel dual wireless EEG system Mobita (TMSi). Electrode placement corresponded to the international 10-20 system. A high viscosity electrolyte gel SuperVisc (EasyCap, GmbH, Germany) was used to ensure good contact between electrodes and scalp, and electrode impedance was typically kept below 20 k Ω . Data were sampled at 500 Hz, and the ground electrode was placed at the vertex. Continuous data were acquired using AcqKnowledge 5.0 software (Biopac Systems, UK). Channels that showed a high general level of noise were manually identified and removed. Recordings were then re-referenced to the average of all channels. The resting state data was then segmented into 2s non-overlapping epochs. Each epoch was baselined (taking the epoch average value) and linear detrended (to remove drifts and slow trends). Epochs with peak amplitude larger than ± 150 μ V were automatically rejected. Following previous dual-EEG studies [1], EEG analysis was focused on the Theta (4-7 Hz) and Alpha (8-12 Hz) frequencies. Accordingly, the concatenated data were bandpass filtered in each frequency range, and the Phase Locking Value (PLV; [2]) was computed between therapist-client electrode pairs in frontal (F3, F4, Fz, FC1, FC2, FC5, FC6) and central (FC1, FC2, C3, C4, CP1, CP2) regions of interest, for each 2s resting state epoch. For each dyad, the average PLV score across all epochs and pairwise connections for each region of interest was computed for each resting state task. The average PLV index across the two resting state tasks was then used for statistical analysis, yielding 4 mean PLV scores per dyad (corresponding to interpersonal frontal Alpha, frontal Theta, central Alpha and central Theta respectively). To conduct statistical analysis, the mean PLV data were entered into a General Linear Mixed Effects Model taking Mindfulness Group [2 levels; mindful/non-mindful] and Interaction Modality [2 levels; face-to-face/online] as between-subjects effects and Electrode Location [2 levels; frontal/central] and Frequency Band [2 levels; Alpha/Theta] as within-subjects effects.

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