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RESEARCH ARTICLE

# Clients' and therapists' parasympathetic interpersonal and intrapersonal regulation dynamics during psychotherapy for depression

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**Abstract**

*Objective* The literature on affective regulation in psychotherapy has traditionally relied on explicit client self-report measures. However, both clients' and therapists' affect fluctuate moment-to-moment during a session, highlighting the need for more implicit and continuous indices to better understand these dynamics. This study examined parasympathetic interpersonal and intrapersonal regulation dynamics between therapists and clients with Major Depressive Disorder during Supportive-Expressive Therapy.

*Method* Data were collected from 52 dyads across five preselected sessions, using the Respiratory Sinus Arrhythmia (RSA) index. We employed a longitudinal Actor-Partner Interdependence Model, with clients self-reporting their functioning level before and after each session, as the moderator.

*Results* Therapists' RSA at one time point negatively associated with clients' RSA at the next, and vice-versa, indicating interpersonal regulation. Clients' RSA at one time point was positively associated with their RSA at the next, indicating intrapersonal regulation. However, only interpersonal regulation was significantly moderated by clients' pre-to-post session functioning. Specifically, sessions where clients led positive dyadic RSA associations showed greater improvement in clients' functioning than those led by therapists.

*Conclusion* Physiological interpersonal regulation, measured by RSA, may be a catalyst for change in depression treatment. Therapists who are responsive to clients' arousal levels may help clients improve their functioning.

**Keywords:** depression; affect regulation dynamics; parasympathetic nervous system; respiratory sinus arrhythmia (RSA)

**Clinical or methodological significance of this article:** This study emphasizes the importance of examining the affective physiological dynamics between client and therapist as well as within the client during psychotherapy for depression. The findings suggest that therapists' responsiveness to their clients' physiological arousal enables the clients to achieve better treatment outcomes.

There is growing evidence that one of main factors underlying Major Depressive Disorder (MDD) lies in difficulties in affective regulation dynamics (Joormann & Stanton, 2016). Depressed individuals tend to experience more blunted affect and lower arousal levels than individuals who are not depressed (Bylsma et al., 2008). However, when depressed individuals do experience negative affect, it tends to be characterized by greater peaks of heightened arousal that last longer (Joormann & Stanton, 2016). Evidence for the notion that regulation dynamics is not only a maintaining factor but also a promising target for the treatment of MDD comes from psychotherapy studies showing that efforts to increase clients' regulation dynamics are associated with a reduction in depressive symptoms (Carryer

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& Greenberg, 2010; Pos et al., 2017; Radkovsky et al., 2014).

Until recently, most of these studies relied on clients' subjective reports of their regulation efforts (e.g., Bar-Kalifa & Atzil-Slonim, 2020). Put differently, these studies assessed explicit evaluations rather than automatic regulatory processes. However, such explicit measures of regulation dynamics draw heavily on clients' capability and willingness to communicate their efforts and difficulties (Cummins et al., 2015). A review of the literature (cf., Joormann & Stanton, 2016) concluded that to better understand regulation dynamics in depression, more implicit affect responses such as physiological arousal and regulation dynamics should be considered.

Despite the growing realization in psychotherapy that regulation processes should be studied at both the intrapersonal as well as the interpersonal level (Atzil-slonim & Tschacher, 2019), most studies have focused on clients' intrapersonal regulation, while neglecting the interpersonal aspects of the regulatory process (for exceptions, see Paz et al., 2021; Soma et al., 2019). *Intrapersonal* affective regulation can be defined as the dynamic influence of affective arousal over time within individuals (Balderrama-Durbin et al., 2021; Gross, 2015; Kuppens & Verduyn, 2015; Wieder & Wiltshire, 2020). *Interpersonal* affective regulation can be defined as the dynamic reciprocal influence of affective arousal over time between interacting partners (Butler & Randall, 2013; Butler & Randall, 2013; Saxbe & Repetti, 2010).

Empirical findings on intrapersonal affective regulation dynamics in psychopathology tends to be inconsistent (Kuppens et al., 2022). While some studies suggest that adaptive intrapersonal regulation dynamics are characterized by flexible changes in affective arousal from one time point to the next (Houben et al., 2015; Koval et al., 2013), other studies have found that unstable affective arousal is associated with greater psychopathology (e.g., Henry et al., 2001; Snir et al., 2017). The psychotherapy theoretical literature suggests that the ability to sustain and tolerate affective arousal over time within a therapy session can be beneficial, because it potentially allows clients to expand their range of affective experiences and improve their functioning (Fosha, 2001; Greenberg, 2012; Mccullough & Magill, 2009). However, this theoretical perspective has not yet been explored in psychotherapy research, particularly concerning physiological affective arousal.

Many psychotherapy theories point to the importance of affective interpersonal regulation between clients and therapists within a session (Fosha, 2001; Winnicot, 1971). According to these theories, psychotherapy seeks to provide clients whose development was compromised by a lack of early interpersonal regulation with emotionally attuned caregiver, a corrective affective experience that replicates more optimal development (Fosha, 2001; Winnicot, 1971). The opportunity to experience feelings, together with an authentic and emotionally present other who is skilled in managing intense affects may help the client develop more productive regulation capabilities (Greenberg & Watson, 2006; Russell & Fosha, 2008). These dyadic processes are expected to lead to better treatment outcomes.

In recent years psychotherapy research has taken a growing interest in client-therapist dyadic processes (Atzil-slonim & Tschacher, 2019). To date, most studies exploring dyadic dynamics in psychotherapy have tended to focus on synchrony, which is based on the idea that therapeutic interactions involve ongoing coordination (i.e., as manifested in statistical correlations) between clients and therapists (e.g., Koole & Tschacher, 2016). However, analyses of the associations between synchrony and treatment outcomes have yielded mixed results (e.g., Atzil-Slonim et al., 2023). Although several studies have reported that synchrony is associated with positive outcomes (e.g., Imel et al., 2014; Tschacher & Meier, 2019), others have failed to find any association or found that synchrony was associated with negative outcomes (e.g., Altmann et al., 2019; Lutz et al., 2020; Ramseyer, 2019; Reich et al., 2014).

Researchers have suggested that to better understand how dyadic affective dynamics lead to clients' improvement in psychotherapy, both the sign and the direction of the association need to be considered (Kleinbub, 2017; Palumbo et al., 2017). The *sign* of an association indicates whether the dyad's correlation is positive (i.e., in-phase) or negative (i.e., anti-phase). During an in-phase pattern, the therapist and client move in the same direction of arousal (both showing more or less arousal), whereas in anti-phase pattern their arousal moves apart from each other; i.e., more vs. less arousal (Kleinbub, 2017; Palumbo et al., 2017).

The *direction* of the association relates to whose arousal comes first over time (whether the therapist's arousal precedes the client's arousal or vice-versa). It remains unclear which direction of influence is most closely associated with improvement in treatment outcomes. For example, when therapists' affective arousal precedes their clients' affective arousal, the therapist may be attempting to lead the client toward a more corrective affective experience (Fosha, 2001). On the other hand, when clients' affective arousal influences therapists' affective arousal, it may reflect the therapists' attunement to their clients' affective states (Greenberg & Watson, 2006; Russell & Fosha, 2008 Watson & Wiseman, 2021).

Studies outside the clinical field have shown that considering both the sign and the direction of interpersonal affective regulation is crucial to a range of outcomes (Armstrong-Carter et al., 2021; Boeve et al., 2019; Connell et al., 2015; Lunkenheimer et al., 2015; see also Thorson et al., 2018). For example, Lunkenheimer et al. (2015) found that mothers and their children tended to have in-phase physiological interpersonal regulation dynamics during lab task interactions. However, when children demonstrated more externalizing behaviors, the interpersonal regulation dynamics tended to show anti-phase patterns in both directions.

Researchers in the clinical field have only recently begun integrating these parameters into their models (e.g., Bryan et al., 2018; Wieder & Wiltshire, 2020). In a study on the vocal channel, Wieder and Wiltshire (2020) found that therapists' in-phase leading of vocal arousal levels was associated with beneficial treatment outcomes. The vocal channel makes it easier to observe mutual influences. By contrast, the sign and direction of interpersonal affective regulation dynamics from one time point to the next in channels such as physiology have rarely been examined in psychotherapy. Nevertheless, understanding client-therapist regulation dynamics over time while considering these parameters may be particularly important for the parasympathetic nervous system, given its central role of this system in the physiological regulatory activity.

## Parasympathetic Regulation

The Autonomic Nervous System (ANS) is a peripheral biological system consisting of the sympathetic and the parasympathetic nervous system which is widely considered to reflect affective arousal (Barrett Feldman et al., 2016). According to Polyvagal Theory, the parasympathetic branch is responsible for affect regulation processes (Porges, 2007). The myelinated vagus nerve, also known as the "vagal brake", plays a key role in promoting balance and relaxation in the body. However, when faced with the perception of a challenging event (i.e., threat or intense emotion), the vagal brake is released, leading to increasing metabolic activity (Porges, 2001, 2007). The parasympathetic nervous system regulates the activity of organs such as the heart and thus influences individuals' sense of affective arousal (Levenson, 2014; Vianna & Tranel, 2006).

Respiratory Sinus Arrhythmia (RSA) is a well-established biomarker of the parasympathetic nervous system that is known to be influenced by vagal innervation of heart activity (Berntson et al., 1993; Porges, 2007). RSA is calculated by applying a frequency power analysis to extract the high-frequency band from the heart rate inter-beat interval (IBI) signal obtained from a wearable electrocardiographic device (Beauchaine, 2015).

In the last two decades, research has consistently reported associations between a decrease in RSA and RSA fluctuation during affectively loaded situations, with poorer regulation capabilities in individuals suffering from depression (Beauchaine, 2015; Määttänen et al., 2019; Schiweck et al., 2019). Several studies outside the clinical field have used RSA to study interpersonal regulation (Palumbo et al., 2017). Armstrong-Carter et al. (2021) reported the presence of RSA interpersonal regulation in 94 children and their parents during a problem-solving task. Their findings indicated that when the parents' RSA increased, the child's RSA increased 30 s later (i.e., parent leading in-phase correlation), whereas when the child's RSA increased, the parents' RSA decreased 30 s later (i.e., parent-following anti-phase correlation). Another study reported an association between RSA interpersonal regulation and relationship outcomes in 32 romantic couples during a conversation task (Helm et al., 2014) and showed that there was a strong in-phase bi-directional correlation (i.e., males' RSA at one time point was associated with females' RSA at the next time point and vice-versa). This correlation was stronger in couples with better-quality relationships.

Only one study that we are aware of has examined the association between clients' and therapists' RSA in psychotherapy (Bar-Kalifa et al., 2023). Their findings showed that client-therapist RSA synchrony was associated with session outcome, and that this association was moderated by the clients' emotional valence. Specifically, therapist-client dyads showed greater synchrony during productive emotional experiences (compared to moments of unproductive emotional experience), and that this synchrony was associated with clients' favorable evaluations of the session. However, this study assessed clients' and therapists' RSA simultaneously and dealt with synchrony rather than regulation. Thus, the sign and direction of parasympathetic influence between client and therapist from one time point to the next, and the ways in which these affective regulation dynamics are differentially associated with session outcome have yet to be explored.

## The Present Study

The present study examined physiological interpersonal regulation dynamics between clients and therapists as measured by RSA, as well as clients' intrapersonal regulation dynamics, moment-by-moment, during therapeutic sessions. More broadly it examined the ways in which these affective regulatory dynamics were associated with session-level outcome in the treatment of depression. During five pre-scheduled sessions throughout a short-term Supportive-Expressive Psychodynamic (SEP) psychotherapy (Luborsky et al., 1995), client-therapist parasympathetic systems were monitored intensively using an RSA index.

To assess closely align with the time resolution of vagal activity and its oscillating pattern, we created a continuous time series of RSA (based on Gates et al., 2015; see also: Bar-Kalifa et al., 2023; Creavy et al., 2020; and Somers et al., 2020). We then employed a longitudinal Actor-Partner Interdependence Model (APIM; Cook & Kenny, 2005) to examine how interpersonal regulation (i.e., the extent to which one member of the therapeutic dyad's RSA at one time point was associated with the other member of the dyad's RSA at a previous time point) and intrapersonal regulation (i.e., the extent to which the client's RSA at one time point was associated with their RSA at a previous time point) were associated with the client's changes in pre- to post-session functioning.

**Prerequisite hypothesis.** Based on previous studies that have examined client-therapist physiological associations (Bar-Kalifa et al., 2019; Ramseyer, 2019; Tschacher & Meier, 2019), we predicted that real dyads' associations from one time point to the next would exceed chance (i.e., we compared the real dyads to a randomly paired pseudo dyad distribution). This prerequisite hypothesis was formulated to rule out the possibility of a random association between two oscillating signals such as in RSA.

**Main hypotheses.** Consistent with previous studies outside the clinical domain which have found evidence for RSA interpersonal and intrapersonal regulation dynamics and positive outcomes (Armstrong-Carter et al., 2021; Balderrama-Durbin et al., 2021; Helm et al., 2014; Somers et al., 2021), as well as psychotherapy studies that have reported an association between treatment outcomes and regulation dynamics in other channels such as vocal arousal (e.g., Bryan et al., 2018; Paz et al., 2021; Wieder & Wiltshire, 2020), the following hypotheses were tested:

> **Hypothesis 1: Parasympathetic interpersonal regulation**. We expected to find interpersonal regulation dynamics such that the therapists' parasympathetic arousal at one time point would be associated with their clients' parasympathetic arousal at the next time point and vice-versa (Hypothesis 1a). We also expected that this interpersonal regulation dynamics of parasympathetic arousal would be moderated by the extent of the clients' pre- to post-session improvement in functioning (Hypothesis 1b). We further explored whether the dyads' parasympathetic arousal would move towards or away from each other (i.e., in-phase or anti-phase) and whether one direction rather than the other would be more strongly associated with clients' improvement in pre- to post- session functioning. Given the inconclusive literature on the direction and the sign of the association in the physiological channel, this hypothesis was exploratory.

> **Hypothesis 2: Parasympathetic intrapersonal regulation**. In terms of the clients' intrapersonal regulation dynamics, we predicted that clients' parasympathetic arousal at one time point would be associated with their parasympathetic arousal at the next time point (Hypothesis 2a). We also predicted that this client's parasympathetic intrapersonal regulation dynamics would be moderated by greater improvement in pre- to post-session functioning (Hypothesis 2b). These hypotheses are based on theoretical psychotherapy views (Fosha, 2001; Greenberg, 2012; Mccullough & Magill, 2009).

## Method

The data utilized in this study were derived from a broader project that investigated interpersonal dynamics between therapists and clients diagnosed with MDD. In this project, all clients underwent manualized short-term (16 sessions) Supportive Expressive Therapy adapted for the treatment of depression (Luborsky et al., 1995). The key features of this model include the use of supportive techniques (such as affirmation and empathic validation) and expressive techniques (such as interpretation, confrontation, clarification). This project took place in the community clinic of the Psychology Department at Bar-Ilan University and received approval from its associated IRB.

### Participants

**Clients.** Fifty-two individuals diagnosed with MDD were included in the sample. To be eligible, individuals had to meet the primary diagnosis of MDD as determined by the Mini-International Neuropsychiatric Interview version 5.0 (MINI; Sheehan et al., 1998). In addition, individuals had to score either (a) 14 or higher on the 17-item clinician-administered semi-structured interview version of the Hamilton Rating Scale for Depression (HRS-D; Williams, 1988) or (b) 17 or higher on the 21-item self-report Beck Depression Inventory-II (BDI-II; Beck et al., 1996). Forty-seven of the 52 clients met the MINI and HRS-D criteria (HRS-D: M = 18.54, SD = 3.61), and 40 of the 52 clients met the MINI and BDI-II criteria (BDI-II: M = 26.65, SD = 6.58). All the clients in this study were adults aged 18 years or older (M = 35.77 years, SD = 9.15, age range 21–61 years), and were not included if they presented with active suicidality, psychosis, addictions, bipolar disorder, brain damage, were currently pregnant, or had heart problems. Most of the clients were female (34 women and 18 men). Twenty-eight of the clients were married or in a committed relationship, 21 were single, and 3 were divorced. In terms of the level of education and job status, 37 participants had at least a bachelor's degree and 44 were either fully or partially employed. The majority were Israeli-born (39 clients); of the remainder, 10 clients were born in the Soviet Union, 1 in France, and 2 who did not report their country of origin. Of the clients, 44 were native Hebrew speakers, 7 were native Russian speakers, and 1 failed to complete this item.

**Therapists.** Thirteen therapists (7 women and 6 men) participated in this study. All the therapists were advanced trainees at the university clinic, with 2–6 years of experience. They were given weekly supervision by senior supervisors who are highly proficient in SEP psychotherapy. The distribution of clients per therapist varied: five therapists treated 5–9 clients each, six treated 2–4 clients each, and two therapists treated 1 client each. The number of clients per therapist was contingent on therapist case load availability at the community clinic. The average age of the therapists was 32.2 years (range: 28–41).

## Procedure

To recruit participants for this study, advertisements were posted on social network platforms offering short-term psychodynamic therapy for symptoms related to depression. Applicants were assessed by a clinical assessment team consisting of MA-level clinical trainees who received group supervision from senior clinicians. A total of 215 individuals were screened using the BDI-II. Of these, 129 individuals with BDI-II scores ≥17 were asked to come for an intake interview, during which the above-mentioned inclusion and exclusion criteria were assessed (the BDI-IIs were re-collected during the intake phase). Fifty-nine clients started therapy. Throughout therapy, all sessions were recorded. Clients completed questionnaires before and after each session to assess their progress and experiences during the sessions. Physiological activity was recorded over the course of 5 sessions (primarily in sessions 2, 5, 8, 11, and 14) using electrocardiography (ECG) for both the clients and their therapists. Due to technical problems (e.g., the Wi-Fi signal was cut off or the electrodes fell off) and signal problems that were considered likely to occur during the preprocessing phase (see details below), 205 sessions were analyzed out of the 260 collected measurements. Overall, of the 59 clients initially included in the study, 2 were excluded due to dropout, 3 were excluded after they required psychopharmacological treatment during therapy, and 2 were excluded due to excessive signal problems. This left a final sample of 52 dyads.

## Measures

**Outcome rating scale (ORS).** The ORS (Miller & Duncan, 2003) is a four-item visual analog scale developed as a brief alternative to the Outcome Questionnaire-45 (OQ-45; Lambert et al., 1996). It is designed to assess changes in three areas of client functioning that are widely considered to be valid indicators of progress in treatment: individual functioning, interpersonal relationships, and social role performance. Respondents complete the ORS by rating the items on a visual analog scale anchored at one end by the word *Low* and at the other end by the word *High*. Each item ranges from 0 to 10, with higher scores indicating better functioning. The ORS has demonstrated strong reliability estimates (.87–.96) and moderate correlations between the ORS items and the OQ-45 subscales and total scores (ORS total– OQ-45 total: r = .59). In this study, the ORS was used to operationalize session outcome as the difference between the client's evaluation of personal functioning reported at the end versus the beginning of the session (i.e., ORS difference; see Paz et al., 2021).

**Respiratory sinus arrythmia (RSA).** An integrated system and software package (Mindware Technology, Gahanna, OH) was used to record the ECG from the therapeutic dyad at a sample rate of 1 kHz. The recordings were conducted using wireless mobile devices attached to each participant (client and therapist), with three disposable electrodes: one on the right clavicle and two on the lower bones of the thorax (one on each side). The signals were transmitted to a computer in an adjacent room and captured using BioLab Software 3.3.1 (Mindware Technology Ltd.). Data were processed offline using HRV Analysis 3.2.7 (Mindware Technology Ltd.). The preprocessing procedure involved automatically identifying suspected artifacts based on the overall R-R distribution using the Shannon Energy Envelope algorithm (Manikandan &

Soman, 2012). Then R-peaks were deleted or inserted based on visual inspection by five trained research assistants (in windows of 45 s). For purposes of the current study, the data were analyzed from the "working phase" of each therapy session, which was defined based on Auszra et al. (2013) as the 15-minute period before the final 5 minutes of the session. This phase is considered to be the part of the session in which clients are most likely to be engaged in therapeutic work. In the current study, the percentage of problematic R-peaks was negligible (Average = 0.1%, Range = 0%−1.6%).

To create the RSA signals we used the RHRV package in R software version 3.7 (R Foundation), implementing the procedure outlined by Gates et al. (2015). This involved tapering the data with a Hanning window and applying a Short-Time Fast Fourier Transform to generate 32-second estimates of RSA from 1-second consecutive windows (i.e., for each 32 s window, RSA value was estimated; for a similar procedure see also Bar-Kalifa et al., 2023; Creavy et al., 2020; Somers et al., 2021). Many previous studies have typically calculated RSA estimates using epochs lasting 60–120 s to ensure a sufficient number of IBI data points for accurate power quantification across frequency ranges (Gates et al., 2015). However, this epoch duration may be too long to capture the rapid fluctuations in RSA that occur during interactions and might not be necessary to obtain precise power estimates within the RSA-associated frequency band (Hansson & Jönsson, 2006). As a result, we used windows consisting of 32-second epochs, which previous research suggests as the shortest duration that can reliably estimate RSA with enhanced temporal resolution (Gates et al., 2015; Hansson & Jönsson, 2006). The integral power within the typical respiratory frequency band for adults (0.12-0.40; Berntson et al., 1997) was used to quantify the RSA within each window.

## Data analysis

The models below integrated a lag to examine the temporal association from one time point to the next. Based on previous studies that have examined dyadic regulation dynamics with RSA, the lag length was set to t minus 30 s (i.e., t-30; e.g., Armstrong-Carter et al., 2021; Helm et al., 2014; Lunkenheimer et al., 2015).

To examine the prerequisite hypothesis, we compared the correlations of the observed dyad data to a null hypothesis distribution generated from pseudo data (Bar-Kalifa et al., 2019; Ramseyer & Tschacher, 2011). Specifically, we created the pseudo dyads distribution by pairing 5,000 randomly selected time-series sequences of arbitrary client-therapist dyads from our observed data. Then, we calculated the RSA signal correlation in our therapeutic dyads (i.e., correlating time t of one partner with time t-30 s of the other partner) and assessed where our observed data sample fell within this distribution.

Next, to examine the two main hypotheses, because the data were nested (seconds nested within sessions and sessions nested within dyads), we used a multivariate multi-level framework (Baldwin et al., 2014), in which clients' and therapists' RSA were modeled simultaneously (the two-intercepts model; Kenny et al., 2006). Their residuals were allowed to vary within session (Level 1), between session (Level 2), and between dyads (Level 3). This APIM (see Figure 1) was adapted from Thorson et al. (2018). The model included both the autoregressive prediction of intrapersonal regulation (i.e., the association of one member of the therapeutic dyad's RSA measure at time t with his or her own RSA measure at time t-30) and the cross-lagged prediction of interpersonal regulation (i.e., the association of one dyad member's RSA measure at time t with the other member of the therapeutic dyad's RSA measure at time t-30). In addition, the model included the interaction of these two variables (i.e., intrapersonal and interpersonal regulation) with the variable of clients' post minus pre session functioning (i.e., ORS difference), as a moderator. Incorporating a conceptual outcome variable as a statistical moderator is a commonly employed approach in multilevel modeling (e.g., Paz et al., 2021; Thorson et al., 2018), where a higher-level variable (e.g., level-2) is incorporated to predict random parameters associated with lower-level variables (e.g., random intercept; see Hoffman, 2015, Chapter 7 for more information).

The hypotheses were tested according to the model shown in Equation 1. Dummy codes (i.e., Therapist and Client) were included to obtain separate fixed effects for therapists and clients. The letters T and C were added to the equation to label the parameters. The predictors were mean centered: $RSA^{T/C}_{(t-30)sd}$ within the session and $ORSDiff_{sd}$ within dyad, as shown below.

***Equation 1:***

**Level 1:**

$$RSA_{tsd} = Therapist*(\beta^{T}_{0sd} + \beta^{T}_{1sd}*RSA^{T}_{(t-30)sd} + \beta^{T}_{2sd}*RSA^{C}_{(t-30)sd} + e^{T}_{tsd}) + Client *(\beta^{C}_{0sd} + \beta^{C}_{1sd}*RSA^{C}_{(t-30)sd} + \beta^{C}_{2sd}*RSA^{T}_{(t-30)sd} + e^{C}_{tsd})$$

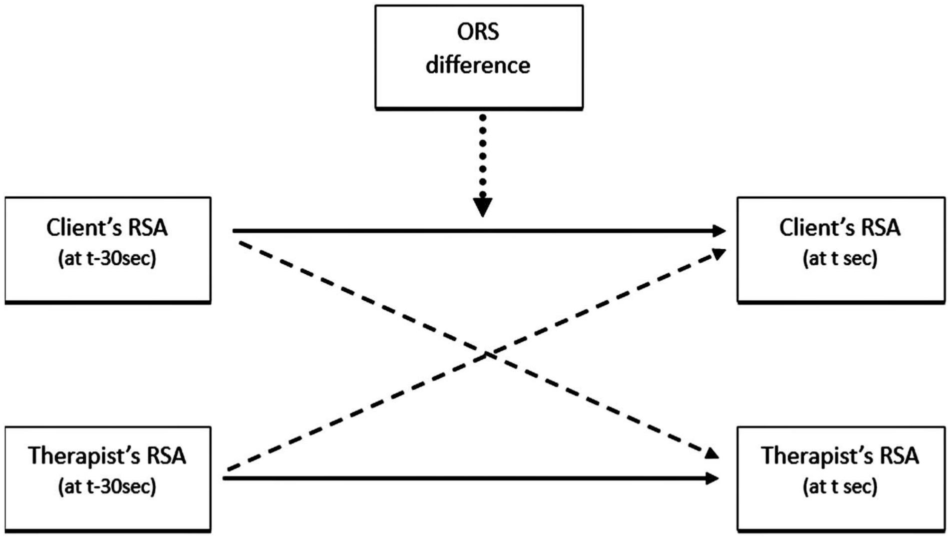


Figure 1. The Actor-Partner Interdependence Model (APIM). Solid lines indicate the autoregressive association of intrapersonal regulation dynamics, that is the association of one member of the therapeutic dyad's RSA measure at time t with his or her own RSA measure at time t-30 s. Dashed lines indicate the cross-lagged association of interpersonal regulation dynamics, that is the association of one's RSA measure at time t with the other member of the therapeutic dyad's RSA measure at time t-30 s. The dotted line indicates the moderation of these intra-personal and interpersonal regulation dynamics with the outcome variable, i.e., the ORS difference.

**Level 2:**

$$\beta_{0sd}^{T/C} = \pi_{00d}^{T/C} + \pi_{01d}^{T/C} * ORSDiff_{sd} + r_{0sd}^{T/C}$$
$$\beta_{1sd}^{T/C} = \pi_{10d}^{T/C} + \pi_{11d}^{T/C} * ORSDiff_{sd}$$
$$\beta_{2sd}^{T/C} = \pi_{20d}^{T/C} + \pi_{21d}^{T/C} * ORSDiff_{sd}$$

**Level 3:**

$$\pi_{00d}^{T/C} = \gamma_{000}^{T/C} + u_{00d}^{T/C};\ \pi_{01d}^{T/C} = \gamma_{010}^{T/C}$$
$$\pi_{10d}^{T/C} = \gamma_{100}^{T/C};\ \pi_{11d}^{T/C} = \gamma_{110}^{T/C}$$
$$\pi_{20d}^{T/C} = \gamma_{200}^{T/C};\ \pi_{21d}^{T/C} = \gamma_{210}^{T/C}$$

The client's RSA at time *t* for session *s* in dyad *d* was estimated at Level-1 by the fixed effects: the intercept ($\gamma_{000}^{C}$), the client's intrapersonal regulation (i.e., the *actor's* RSA at time *t-30* sec; $\gamma_{100}^{C}$) and by the therapist's interpersonal regulation (i.e., the *partner's* RSA at time *t-30* sec; $\gamma_{200}^{T}$). The therapist's RSA at time *t* for session *s* in dyad *d* was estimated in the opposite way; that is, the therapist as the *actor* and the client as the *partner*. A positive value indicates an in-phase correlation between the client's RSA at time t to either his or her own RSA at time *t-30* sec or the therapist's RSA at time *t-30* sec, whereas a negative value indicates an anti-phase correlation.

At Level-2, the pre- to post- session difference in ORS was added as a moderator of the intrapersonal regulation and interpersonal regulation slopes. In addition to the main effect for difference in ORS ($\gamma_{010}$), cross-level interactions ($\gamma_{110}$ *and* $\gamma_{210}$) examined whether sessions characterized by higher intrapersonal regulation and interpersonal regulation were associated with greater improvement in clients' pre- to post-session functioning. Random effects ($e_{tsd}^{T/C}$, r0sd, $u_{00d}$)were added to the equation.[1] Figure 2 illustrates interpersonal and intrapersonal affective regulation dynamics drawn from one good and one poor outcome sessions.

Finally, to explore which interpersonal regulation direction of influence (the clients' RSA precedence the therapists' RSA or vice-versa) had a stronger moderation effect with ORS difference, we conducted a contrast analysis between the two interactions slopes; that is, $\pi_{21d}^{T/C}$.

## Results

### Prerequisite Analysis

As illustrated in Figure 3, the correlation between the observed dyad data at time t and time t-30 s (r = 0.013, SD = 0.0014), as represented by the dotted vertical red line, exceeded the upper limit of the 95% confidence interval in comparison to the pseudo-sampling distribution, as indicated by the solid vertical lines. This indicated that the correlations in the actual client-therapist signals were likely to be non-random.

### Parasympathetic Interpersonal Regulation

The results are presented in Table I. Confirming Hypothesis 1a, the findings indicated a significant

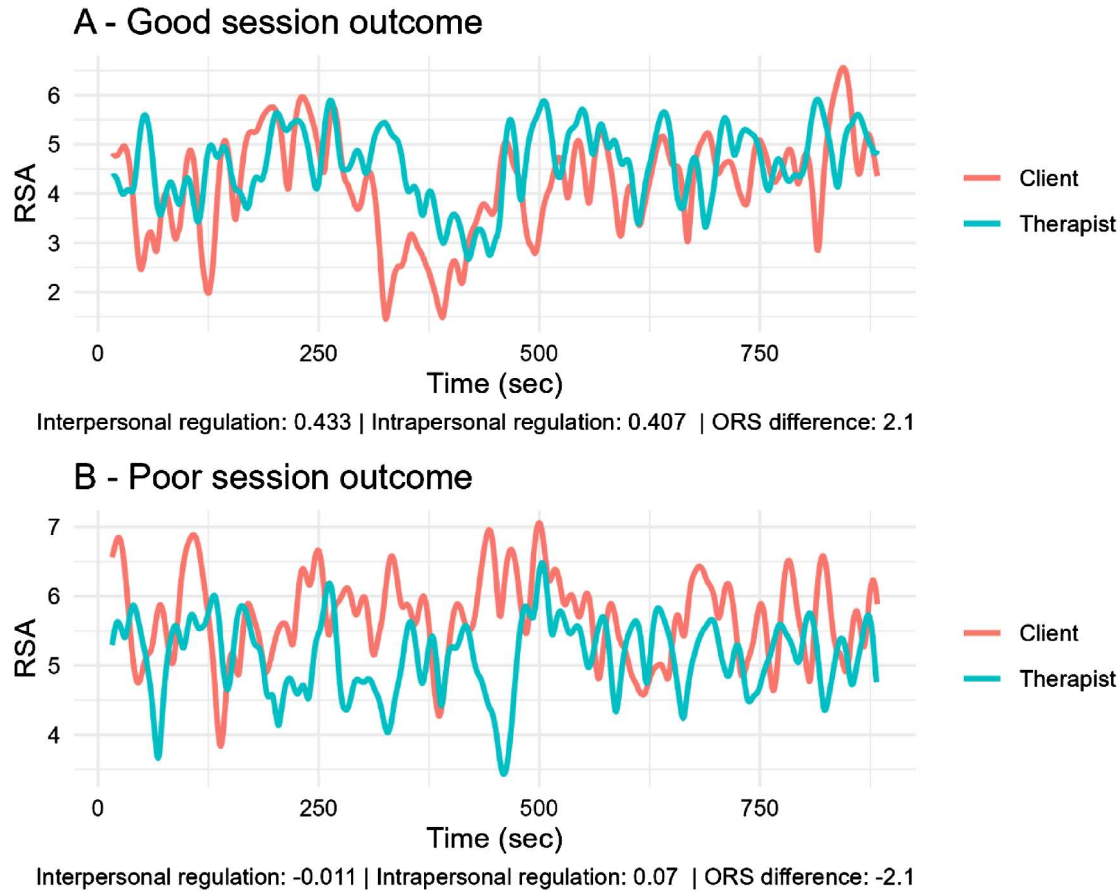


Figure 2. Illustration of interpersonal and intrapersonal affective regulation dynamics drawn from one good and one poor outcome session. Client's RSA in red, and therapist's RSA in blue. Upper panel A depicts a good session's ORS difference with higher client-leading interpersonal regulation dynamics (i.e., higher client influence of physiological affective arousal at time t-30 s on therapist physiological affective arousal at time t) and higher client intrapersonal regulation dynamics (i.e., higher client stability of physiological affective arousal from time t-30 s to time t). Bottom panel B depicts a relatively poor ORS difference with lower client-leading interpersonal regulation dynamics and lower client intrapersonal regulation dynamics data. The interpersonal and intrapersonal regulation estimates (presented in each panel) were calculated from simple linear regressions.

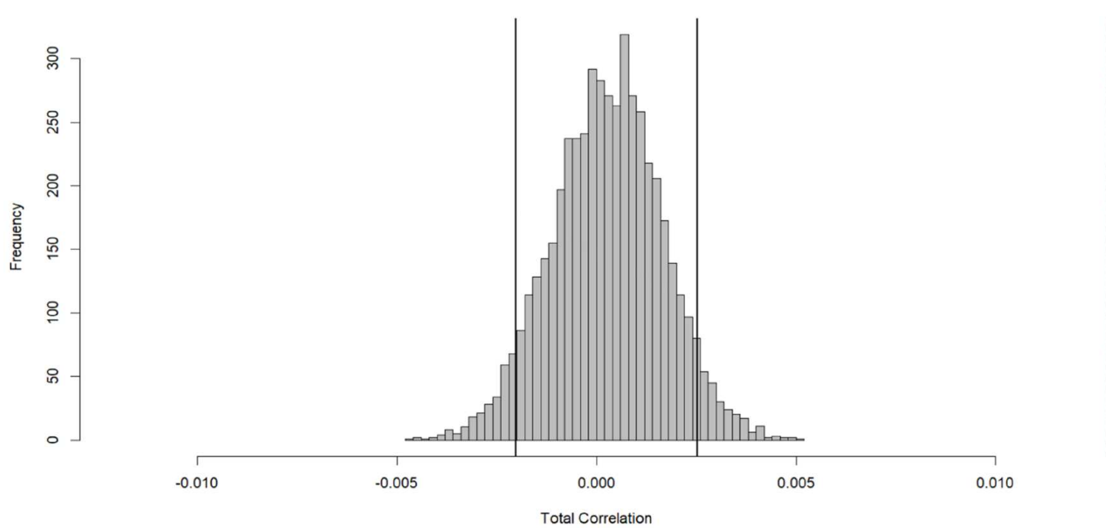


Figure 3. Comparison of the correlation coefficient for real dyads to the pseudo-dyads sampling distribution. The null hypothesis was generated by pairing 5,000 randomly selected time-series with a confidence interval of 5%–95%. Red dashed line indicates the correlation coefficient for the real dyads.

anti-phase interpersonal regulation of the therapists' RSA at time t-30 s with their clients' RSA at time t, and vice-versa. In line with Hypothesis 1b, the interpersonal regulation effects were significantly moderated by clients' difference in functioning from pre- to post-session. To probe this interaction, we computed the client and therapist parameters at 1 SD above and below the baseline.[2] For the therapist-leading interpersonal regulation direction, when the ORS difference was lower (i.e., 1 SD below the mean) the interpersonal regulation was more anti-phase (Est. = −0.032, SE = 0.004, $p < 0.001$) than when ORS difference was higher (i.e., 1 SD above the mean; Est. = −0.022, SE = 0.003, $p < 0.001$). Similarly, for the client-leading interpersonal regulation direction, when the ORS difference was lower, the interpersonal regulation was more anti-phase (Est. = −0.028, SE = 0.004, $p < 0.001$) than when the ORS difference was higher (Est. = −0.008, SE = 0.003, $p = 0.110$). In other words, for both directions (i.e., client preceding therapist and vice-versa), sessions characterized by higher ORS differences tended to exhibit more in-phase interpersonal regulation.

Table I. APIM results for interpersonal and intrapersonal regulation dynamics, and the moderation with ORS difference.

| | Estimate (SE) | CI 95% | *p* |
|---|---|---|---|
| **Intercepts:** | | | |
| Client | 5.024 (0.161) | 4.709, 5.338 | <.001 |
| Therapist | 5.054 (0.096) | 4.865, 5.242 | <.001 |
| **Interpersonal:** | | | |
| Client | −0.027 (0.002) | −0.032, −0.022 | <.001 |
| Therapist | −0.010 (0.002) | −0.015, −0.005 | <.001 |
| **Intrapersonal:** | | | |
| Client | 0.085 (0.002) | 0.080, 0.089 | <.001 |
| Therapist | 0.017 (0.002) | 0.012, 0.022 | <.001 |
| **Interpersonal X ORS difference:** | | | |
| Client | 0.005 (0.002) | 0.000, 0.009 | <.05 |
| Therapist | 0.016 (0.002) | 0.011, 0.020 | <.001 |
| **Intrapersonal X ORS difference:** | | | |
| Client | 0.002 (0.002) | −0.002, 0.007 | .279 |
| Therapist | −0.004(0.002) | −0.008, 0.000 | .072 |
| **Fit indices** | | | |
| AIC | 759575.3 | | |
| BIC | 759790.5 | | |

SE = Standard Error, CI = Confidence Interval, AIC = Akaike information criterion; BIC = Bayesian information criterion. Client/Therapist: indicates the actor in each line of the table, where "Client" indicates the association of therapists' RSA at time t-30 s with clients' RSA at time t, and "Therapist" indicates the association of clients' RSA at time t-30 s with therapists' RSA at time t.

The contrast analysis between the interaction slopes; i.e., $\pi_{21d}^{T/C}$ , was also significant (Est. = −0.011, SE = 0.003, $p < 0.001$). Specifically, sessions characterized by higher levels of ORS difference tended to exhibit more client leading of the interpersonal regulation. Overall, as illustrated in Figure 4, the comparison of high and low levels of session outcome suggested that sessions characterized by higher ORS differences tended to exhibit greater in-phase interpersonal regulation led by the clients than interpersonal regulation led by the therapists.

## Parasympathetic Intrapersonal Regulation

The results also supported Hypothesis 2a, indicating a significant positive intrapersonal regulation effect of client RSA at time t-30 s on their RSA at time t. However, contrary to Hypothesis 2b, the moderation of this intrapersonal regulation effect by the difference in client pre- to post- session functioning was not significant.

## Discussion

The present study implemented intensive repeated physiological measurements to examine therapists' and clients' interpersonal affective regulation dynamics as well as clients' intrapersonal affective regulation dynamics and their association with outcome during the treatment of depression. These affective dynamics were assessed by measuring clients' and therapists' within-session RSA, a parasympathetic index that is known to be a key measure of affective regulation (Palumbo et al., 2017; Porges, 2007).

As a prerequisite for our analysis, we first ensured that the mutual influence between clients' and therapists' RSA did not occur by chance. As expected, we found significantly stronger associations between clients' and therapists' lagged RSA (i.e., the therapists' RSA at time t-30 s was correlated with the clients' RSA at time t) in real dyads than in the pseudo-dyads' distribution. This is consistent with previous studies which have reported that the coordination between clients' and therapists' signals in various modalities is not random (e.g., Bar-Kalifa et al., 2019; Ramseyer, 2019; Ramseyer & Tschacher, 2011; Tschacher & Meier, 2019).

Consistent with Hypothesis 1a, we found that therapists' parasympathetic arousal at one time point (i.e., time = t-30 s) was associated with their clients' parasympathetic arousal at the next time point (i.e., time = t seconds) and vice-versa (i.e., clients' parasympathetic arousal preceded their therapists' parasympathetic arousal). These results are in line with previous studies indicating ongoing

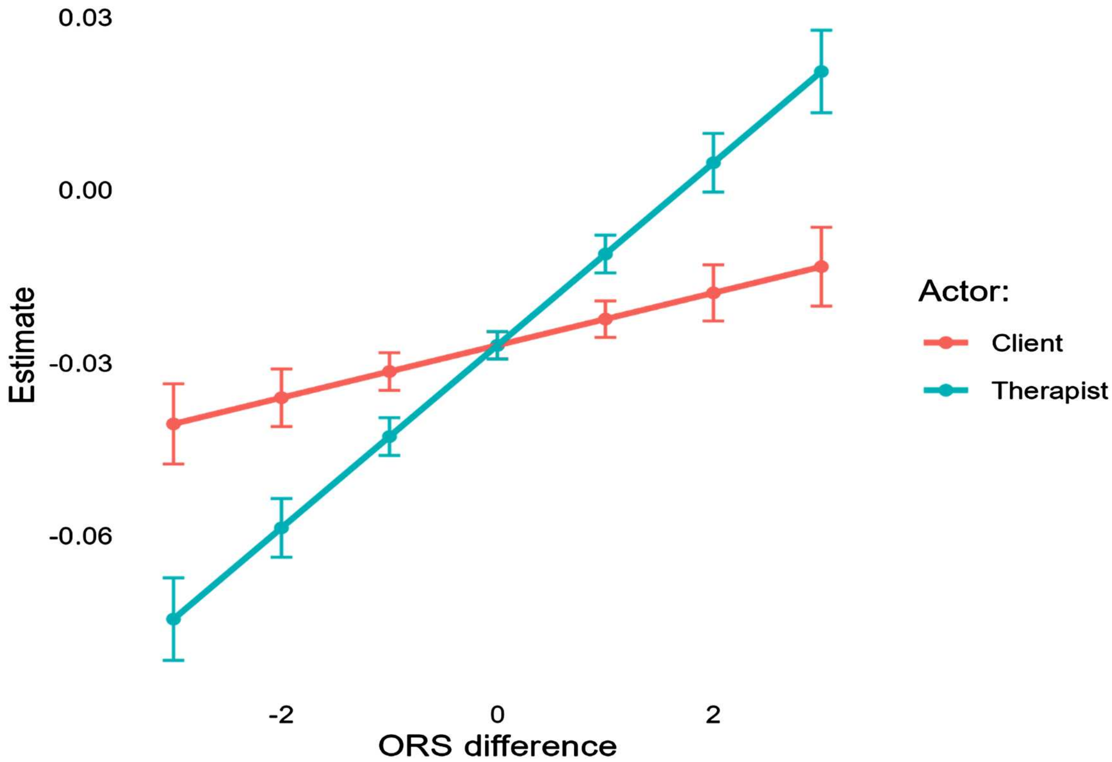


Figure 4. Estimates of parasympathetic interpersonal regulation dynamics and their association with ORS difference. The ORS difference represents the change in clients' functioning from pre-to-post session (i.e., post minus pre), calculated at ±3 SDs. Client/Therapist color coding indicates the influencing party: red represents therapists influencing clients, and blue represents clients influencing therapists. Error bars represent ±1 SEM.

coordination of affective arousal between therapists and clients in various modalities (e.g., Imel et al., 2014; Soma et al., 2019; Tschacher & Meier, 2019). However, unlike most previous studies that have focused on synchrony; i.e., the concurrent associations between the signals of the two parties over time, the current study focused on interpersonal regulation dynamics of the parasympathetic system and demonstrated the mutual influence between these systems from moment to moment in the session. There was a predominance of anti-phase interpersonal regulation (i.e., a negative association of the dyads' parasympathetic activity over time) in both directions; in other words, clients and therapists tended to pull each other in opposite directions, which may suggest their implicit efforts to balance each other's arousal. That is, when one member of the dyad experienced increased arousal (i.e., lower parasympathetic activity), the other member's reaction was to exhibit heightened regulatory efforts (i.e., higher parasympathetic activity).

Consistent with Hypothesis 1b, bi-directional interpersonal regulation dynamics were associated with an improvement in the clients' pre- to post-session functioning. These findings confirm previous studies reporting an association between interpersonal regulation and treatment outcome in the vocal channel (Bryan et al., 2018; Paz et al., 2021; Soma et al., 2019; Wieder & Wiltshire, 2020). Our findings extend these vocal channel data on observable regulation processes by showing the association between interpersonal regulation dynamics and outcome in the parasympathetic system, an internal physiological channel which is known to be responsible for regulatory processes. These findings are also consistent with several contemporary theories that have pointed to the importance of interpersonal regulation dynamics as key transformational factor in psychotherapy (Aron & Harris, 2014; Fosha, 2001; Schore & Schore, 2014).

When considering the sign (in-phase or anti-phase) of the interpersonal regulation dynamics, we found a predominance of in-phase interpersonal regulation dynamics (i.e., positive RSA association of dyads' parasympathetic activity over time) that were associated with clients' improvement in pre- to post- session functioning. Interestingly, although the results showed that the typical client-therapist dynamic in our sample was anti-phase regulation dynamics, good outcome sessions were characterized by in-phase dynamics. This may imply that when depressed clients and their therapists dynamically tuned their affective arousal to match one another, they were more likely to achieve better session outcomes.

In terms of the direction of the interpersonal regulation, the findings indicated that client-leading regulation dynamics (i.e., when the clients' arousal at one time point preceded their therapists' arousal at the next time point), as compared to therapist-leading dynamics, were more strongly associated with improvement in the clients' pre- to post-session functioning, which is consistent with findings in the vocal channel (Bryan et al., 2018). This may suggest that when therapists are physiologically responsive to cues in their clients' level of arousal and follow them closely moment by moment, they are better able to help their clients improve their functioning. This echoes recent studies that highlight the importance of therapists' responsiveness and attunement to their clients' states as they fluctuate throughout a session (Baldwin et al., 2007; Watson & Wiseman, 2021; Zuroff et al., 2010).

Partially consistent with our second hypothesis, clients' intrapersonal regulation dynamics were observed from one time point to next. This finding is in line with previous studies outside the psychotherapy domain which have shown that depressed individuals tend to present more affective arousal stability from one time point to the next (Koval et al., 2013). This result is also consistent with studies that have reported the presence of parasympathetic intrapersonal regulation dynamics during close relationship interactions (e.g., Balderrama-Durbin et al., 2021 with romantic partners dyads; Lunkenheimer et al., 2017 with parent–child dyads), as well as with earlier studies identifying intrapersonal regulation dynamics in psychotherapy through other regulatory channels such as vocal patterns (e.g., Wieder & Wiltshire, 2020). However, contrary to our hypothesis, intrapersonal regulation dynamics were not associated with session-level outcome. Although psychotherapy theories suggest that clients' ability to tolerate and expand their affective arousal during a session can be beneficial (Fosha, 2001; Greenberg, 2012; Mccullough & Magill, 2009), our findings did not indicate that either a stable pattern or a flexible pattern of more implicit physiological affective arousal over time was linked to client improvement in session functioning. One possible explanation is that depressed clients' intrapersonal regulation dynamics may not be sufficient for such improvement, and they may need the combined resources of the dyad to achieve a better outcome (as illustrated by our first hypothesis results).

Overall, the findings underscore the importance of dyadic affective dynamics in psychotherapy and reinforce the notion that therapists who are responsive to their clients' affective arousal may be better able to help their clients regulate their own emotions and eventually achieve better therapeutic outcomes.

## Limitations, Future Directions and Clinical Implications

One limitation of this study is that it focused solely on physiological regulation dynamics related to implicit processes as obtained from a measure of the parasympathetic nervous system. It is important to note that regulation dynamics occur in multiple modalities simultaneously, including the two branches of the ANS (i.e., sympathetic and parasympathetic), which function in a dynamic balance (Barrett Feldman et al., 2016). Thus, to gain a more comprehensive understanding of client-therapist regulation dynamics, future studies should examine the activity of both ANS branches concurrently since one branch is responsible for stress responses, such as the fight-or-flight response, while the other governs regulatory responses, such as rest and digestion. Furthermore, the use of multiple modalities would enable a better understanding of the mechanisms behind their mutual influence over time. It is possible that behavioral cues precede the physiological response and lead to differences in physiological interpersonal regulation dynamics.

In addition, the therapists in this study were trainees delivering psychodynamic psychotherapy treatment for depression, which may limit the generalizability of the findings. Future studies would benefit from exploring interpersonal and intrapersonal regulation dynamics and their association to outcomes with more experienced therapists who implement other therapeutic approaches, and in clients diagnosed with other mental health problems. For example, studies could compare groups of therapists with varying levels of experience to assess whether more seasoned therapists, who have more experience in regulating their own emotions, exhibit greater interpersonal regulation dynamics during sessions. Alternatively, the freshness that comes with inexperience may allow for more pronounced regulatory dynamics to unfold.

Another limitation stems from the model's failure to converge when incorporating random effects for slopes, possibly due to the relatively small sample sizes at the client level ($N = 52$). Consequently, we were unable to investigate differences in interpersonal and intrapersonal regulation dynamics at the between-client level (i.e., "trait-like" effects). Furthermore, while recent research has underscored the importance of contextual factors (i.e., "state-like" effects) when examining interpersonal and intrapersonal affect dynamics (e.g., Mayo & Gordon, 2020), the complexity of our model precluded including these contextual factors which are thus beyond the scope of this study. Future studies with larger client sample sizes or different statistical approaches could examine whether clients' and therapists' trait-like or state-like characteristics influence affect dynamics and treatment outcomes. For example, the presence of trait-like difficulties in parasympathetic regulation dynamics in depressed clients might interact with the association between regulation dynamics and treatment outcomes. Similarly, clients' state-like emotional valence or therapists' specific interventions could interact with the association between regulation dynamics and session outcomes. In addition, future studies could investigate whether interpersonal and intrapersonal regulation dynamics are altered as a function of the treatment phase (i.e., early, middle, and late phases), which would clarify whether these dynamics develop throughout treatment and whether such development is associated with treatment outcome.

Nevertheless, the current findings have important clinical implications that underscore the importance of the implicit interpersonal dynamics that occur during therapeutic sessions between depressed clients and their therapists. Therapists should be cognizant of the potential influence of physiological dynamics between themselves and their clients, which may allow them to better identify how their clients' affective arousal can impact their own. Utilizing their own affective cues in response to their clients' arousal could lead to better treatment outcomes for depressed clients. Recent advances in non-invasive physiological monitoring, coupled with progress in technology in feedback systems may enable therapists and supervisors to detect instances of dysregulation and enable therapists to enhance their ability to regulate affective states. This would help therapists improve their skills and be more attentive and attuned to their clients' affective arousal, thus ultimately facilitating better treatment outcomes.

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## Notes

[1] Level-1 and Level-2 random effects were only modeled for the intercepts since the model did not converge by adding random effects for slopes.

[2] We used Preacher et al.'s (2006) computational tool for probing interaction effects in MLM analyses.

## Disclosure Statement

No potential conflict of interest was reported by the author(s).

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