Nonverbal Synchrony in Psychotherapy:

Coordinated Body-Movement Reflects Relationship Quality and Outcome

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Abstract

Objective: We quantified nonverbal synchrony – the coordination of patient's and therapist's movement – in a random sample of same-sex psychotherapy dyads. We contrasted nonverbal synchrony in these dyads with a control condition and assessed its association with session-level and overall psychotherapy outcome. ***Method:*** Using an automated objective video-analysis algorithm (Motion Energy Analysis, MEA), we calculated nonverbal synchrony in (N = 104) videotaped psychotherapy sessions from 70 Caucasian patients (37 female, 33 male, mean age = 36.5 years, SD = 10.2) treated at an outpatient psychotherapy clinic. The sample was randomly drawn from an archive (N = 301) of routinely videotaped psychotherapies. Patients and their therapists assessed session impact with self-report post-session questionnaires. A battery of pre- and post-symptomatology questionnaires measured therapy effectiveness. ***Results:*** We found that nonverbal synchrony is higher in genuine interactions contrasted with pseudointeractions (a control condition generated by a specifically designed shuffling procedure). Furthermore, nonverbal synchrony is associated with session-level process as well as therapy outcome: It is increased in sessions rated by patients as manifesting high relationship quality, and in patients experiencing high self-efficacy. Higher nonverbal synchrony characterized psychotherapies with higher symptom reduction. ***Conclusions:*** The results suggest that nonverbal synchrony embodies the patients' self-reported quality of the relationship and further variables of therapy process. This hitherto overlooked facet of therapeutic relationships might prove useful as an indicator of therapy progress and outcome.

Keywords: nonverbal synchrony, mimicry, imitation, embodiment, coordinated body-movement

Nonverbal Synchrony in Psychotherapy: Coordinated Body-Movement Reflects Relationship Quality and Outcome

Psychotherapy research has repeatedly shown that the therapeutic relationship is a crucial variable for the success of therapy (Orlinsky, Rønnestad, & Willutzki, 2004). This relationship has been assessed with various methods and its association with outcome is empirically well documented (Horvath & Symonds, 1991; Martin, Garske, & Davis, 2000). Empirical evidence is far less concrete, however, when it comes to specific techniques to establish this therapeutic relationship. What are the ingredients for a good relationship? Experts have suggested that the nonverbal behavior of therapists has a decisive role in relationship formation (e.g. Hall, Harrigan, & Rosenthal, 1995). Most reviewers agree that a therapist's nonverbal behavior influences the quality of the therapeutic alliance (e.g. Philippot, Feldman, & Coats, 2003). Kiesler (1979) pointed out 30 years ago that " the most crucial place to search for relationship is in the nonverbal behavior of the interactants ..." (p. 303). Despite this widely accepted opinion and acknowledgement of the phylogenetic and ontogenetic primacy of nonverbal behavior (Segerstråle & Molnár, 1997), research exploring the bonding process in psychotherapy has focused on speech content rather than nonverbal behavior (Tickle-Degnen & Gavett, 2003). Data indicating how nonverbal behavior may affect therapy outcome and therapy relationship are sparse. Nonverbal aspects of relationship formation have only been assessed at either the level of the patient or the therapist, ignoring the system level of the dyad. This restriction must be critically questioned because the therapeutic relationship arises between the therapist and the patient(s) interacting in therapy.

Tickle-Degnen and Rosenthal (1990) explicitly addressed rapport as one of the necessary conditions in the development of a successful therapeutic relationship. They describe three nonverbal components that shape rapport: attentiveness, positivity-negativity, and coordination.

In the current study, we focused on the aspect of coordinated body-movements between patient and therapist. We will use the term 'nonverbal synchrony' in accordance with Condon and Ogston (1966), who first described the phenomenon of movement coordination between interacting persons as interactional synchrony. Our conceptualization of nonverbal synchrony has three unique features: a) it is a *dynamic* quality (Bernieri & Rosenthal, 1991), i.e. movement characteristics are assessed, irrespective of the specific postures or gestures displayed; b) it is measured *objectively* and *automatically* by a video-computer interface; c) it includes *simultaneous* movement (Condon and Ogston's definition) as well as *time-lagged* coordinated movement in a window of ± 5 seconds. The rationale behind our approach to nonverbal synchrony in psychotherapy is based on the nonverbal components of rapport and on the concept of embodiment (e.g. Gallese, 2005). We hypothesize that synchronous body movement is a manifestation of rapport, and ultimately, relationship quality. This perspective on synchrony is not limited to nonverbal behavior: synchrony is a pervasive concept relevant to physics, biology, and the social sciences, hence is found both in living systems and inanimate nature (Ramseyer & Tschacher, 2006; Strogatz, 2003). Synchrony has been conceptualized from both a neural ('mirror neurons' Iacoboni, 2009) and representational point of view ('neuronal coherence' Rodriguez et al., 1999), as well as from the stance of self-organized behavioral dynamics ('synergetics' Oullier, Guzman, Jantzen, Lagarde, & Kelso, 2008). Nonverbal synchrony can be considered a *Gestalt* which humans are capable of perceiving on a flexible time basis (Bernieri, Reznick, & Rosenthal, 1988), and which does not reside in any particular behavior (Davis, 1981; Grammer, Kruck, & Magnusson, 1998). Here we have adopted a theoretically neutral concept of movement coordination and were interested in the manifestation of coordinated dynamics, not in specific gestures, postures or any other qualitative information. The dynamical systems view (Newtson, 1994; Schmidt & Richardson, 2008; Tschacher & Dauwalder, 2003; Vallacher &

Nowak, 2009) is an appropriate framework for what we defined as nonverbal synchrony.

Nonverbal synchrony in face-to-face interaction

Nonverbal synchrony during interaction has been previously studied in diverse contexts (Bernieri & Rosenthal, 1991; Burgoon, Stern, & Dillman, 1995; Davis, 1982). Synchrony between patient and therapist can manifest itself in a qualitative correspondence between persons: matching of body positions (‘congruent body positions’ Charny, 1966; Maurer & Tindall, 1983; Scheflen, 1964; Trout & Rosenfeld, 1980), imitation of mannerisms (‘chameleon effect’ Chartrand & Bargh, 1999), matching of nonverbal emotional display (‘emotional contagion’ Hatfield, Cacioppo, & Rapson, 1994), but also in a quantitative, dynamic correspondence: nonverbal coordination during interaction (‘nonverbal convergence’ Geerts, van Os, Ormel, & Bouhuys, 2006), or imitation of movement quality (‘interactional synchrony’ Bernieri & Rosenthal, 1991; Condon & Ogston, 1966; Kendon, 1970). Previous studies all suggest that synchrony may be linked to increased relationship quality. Many areas of human social interaction foster synchronized behavior (Vallacher & Nowak, 2009), including religion (chorusing, dancing), sporting events (‘Mexican waves’), and the military (marching). These behavioral examples describe situations where belongingness and mutual liking abound (McNeill, 1995). There are several explanations for the correlation between nonverbal synchrony and relationship quality in psychotherapy. One explanation is that synchrony between therapist and patient increases empathic understanding (Levenson & Ruef, 1997), which in turn improves the quality of a relationship (Bavelas, Black, Lemery, Mullett, & Eisenberg, 1987). Secondly, synchrony may have a communicative function, leading to a common conception of a situation (Bavelas et al., 1987), a common attentional orientation and a similarity in views or roles, which in turn also lead to an increase in liking (Scheflen, 1964; Wallbott, 1996). Interestingly, the term empathy is derived from the German word *Einfühlung* (“feeling oneself into”), which in its early usage specifically referred to objective motor mimicry (Allport, 1961). Recent studies have revealed that synchronized motor activity increases both cooperation (Wiltermuth & Heath, 2009) and liking (Hove & Risen, 2009), and is associated with higher ratings of rapport. Even simple body-movements, such as walking, are more synchronized in dyads with positive relationships (Miles, Griffiths, Richardson, & McCrae, 2010).

An appropriate background for such associations may be evolution theory (Lakin, Jefferis, Cheng, & Chartrand, 2003): Phylogenetically, group-level advantages to survival are evident (e.g. a synchronized flight response in threatening situations; Preston & de Waal, 2002); ontogenetically, shared body expressions of mother-infant interactions are associated with various positive developmental outcomes (Harrist & Waugh, 2002). The perception-action model (Preston & de Waal, 2002) and the shared circuits model (Hurley, 2008) emphasize the importance of the biological foundation of behavioral correspondence.

While many authors have previously suggested that a good relationship is embodied by various forms of synchrony, generalizable empirical evidence from controlled studies in psychotherapy is scarce (Rosenfeld, 1981). Nonverbal synchrony has been sporadically assessed in psychotherapy sessions (overviews: Hess, Philippot, & Blairy, 1999; Ramseyer, 2008). Most of the early psychotherapy studies, however, were based on single cases and anecdotal accounts (Charny, 1966; Scheflen, 1964). Furthermore, the majority of empirical research has been conducted in role-played interactions (Trout & Rosenfeld, 1980), in student populations (Koss & Rosenthal, 1997), or via ratings of therapist behavior (Harrigan & Rosenthal, 1983). Dyads involved in real psychotherapeutic interaction have seldom been assessed directly.

The current study is based on naturalistic psychotherapy data, implemented a randomized sampling procedure, and controlled for synchrony that might be expected by chance. Our main hypothesis is that if nonverbal synchrony exists in psychotherapy interactions, its manifestations will be more pronounced in psychotherapy than in a control condition of ‘pseudointeractions’ (interactions generated by shuffled time-structures; as defined in the methods section below). Our second hypothesis is that a positive correlation exists between the amount of nonverbal synchrony and measures of relationship quality assessed immediately after a therapy session. Finally, we hypothesize that nonverbal synchrony is positively associated with the outcome of therapy, as measured by pre-post therapy assessments (pre-to-post outcome) and retrospective therapy success measures (retrospective outcome).

Methods and Procedures

Participants

Participants (*N* = 70) were 37 women and 33 men (mean age 36.5 years, *SD* = 10.2, all white Caucasian European ethnicity) treated at the outpatient psychotherapy clinic of the University of Bern, Switzerland. This clinic accepts patients suffering from a wide range of problems and disorders, with the exceptions of psychotic disorders and substance dependency. Patients of this sample belonged to the following main diagnostic groups: 34% anxiety disorders, 29% affective disorders, 37% other diagnoses (11.4% adjustment disorders, 8.6% personality disorders, 17% other disorders). Comorbidity was predominantly found in anxiety disorders (58% comorbid patients) and affective disorders (24%). These percentages were considered representative of the database population of *N* = 838 cases: 35.1% anxiety disorders; 24.8% affective disorders; 10.5% adjustment disorder; 4.3% eating disorders; 15% no axis-1 disorder. All diagnoses were assessed prior to therapy using the Structured Clinical Interview (SCID; Wittchen, Zaudig, & Fydrich, 1997) for the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV; American Psychiatric Association, 1994).

Mean psychotherapy duration per patient was 38.1 sessions (*SD* = 22.1, range 8 – 126).

Based on a single-case analysis (Ramseyer & Tschacher, 2008) and further pilot-data (Ramseyer, 2008), an *apriori* power analysis (1- $\beta = 0.80$; $\alpha = .05$) assuming a correlation of Pearson's $r = .35$ between nonverbal synchrony and relationship quality, resulted in a minimal sample size of $n = 62$ patients (124 sessions). The following inclusion criteria were applied to the complete video archive of 301 patients (10,266 sessions): First, only psychotherapy sessions where patient and therapist were of the same gender were included ($n = 197$ patients; 6,441 sessions). This criterion was based on previous research showing that mixed-gender dyads were less prone to exhibit nonverbal synchrony (Grammer et al., 1998). Second, only sessions with recordings on VHS tape were included for analysis ($n = 5{,}152$ sessions). Third, stratification was balanced for gender and phase of therapy (1st third [T1] or 3rd third [T3]). Each dyad thus provided a session from T1 and T3 of the respective therapy, resulting in a total of 160 sessions. Fourth, of these randomly drawn sessions, we selected only those where dyads remained seated throughout, interacting verbally and nonverbally without external constraints on free movement, e.g. through the use of a flip chart or similar device (excluded: 27 sessions). Fifth, overall video-signal quality had to be sufficient for our measure of nonverbal synchrony (excluded: 29 sessions). Application of these inclusion criteria resulted in 104 psychotherapy sessions of 70 dyads: 47 from T1 and 57 from T3 (flow-chart: see Figure W1, web-appendix).

Setting

All sessions (average duration 50 min) were recorded using two cameras joined into a split-screen image (Figure 1A). In general, therapists ($n = 42$) conducted sessions once a week, using cognitive-behavioral psychotherapy (Grawe, 2004). Therapists had heterogeneous backgrounds comprising psychologists from a post-graduate training program in psychotherapy as well as expert therapists ($n = 7$) who worked as supervisors in this program. Filming of therapies was openly declared and carried out as part of routinely administered research activity.

Administration of psychotherapy and recording of sessions was independent of the research on nonverbal synchrony and took place during the years 1998 to 2004, well before the formulation of our research hypotheses. At the time of recordings, patients and therapists gave informed consent complying with Swiss ethical regulation policies for further scientific use of their data.

Motion energy analysis (MEA)

The assessment of nonverbal synchrony has traditionally relied on laborious manual codings of single frames of sound-film recordings (Condon & Ogston, 1966) or on trained judges' evaluations (Bernieri & Rosenthal, 1991). Technical progress has since greatly facilitated quantification of an individual's movement based on videotape recordings (Grammer, Filova, & Fieder, 1997; Grammer, Honda, Schmitt, & Jütte, 1999; Kupper, Ramseyer, Hoffmann, Kalbermatten, & Tschacher, 2010). Motion energy analysis (MEA), an objective method to determine nonverbal synchrony, provides an alternative to manual observer ratings. MEA can be automated to continuously monitor the amount of change occurring in pre-defined regions of interest (Figure 1A). The prerequisites for MEA are a static camera position, stable light conditions, and digitized film material.

Digitized sequences (10 frames /s) of all included therapy interactions were analyzed with commercial video-analysis software ('softVNS' Rokeby, 2006) that was customized for MEA (Ramseyer, 2008; see supplemental online material). Motion energy was defined as differences in grey-scale pixels between consecutive video-frames (Grammer et al., 1999). Detection of frame-by-frame change allows quantification of any change in pre-defined regions of interest. We chose one region per participant, covering the upper body from the chair's seating-base upwards (Figure 1A). Provided that recordings are obtained with a fixed camera position and lighting conditions are kept constant, frame-by-frame change indicates body motion of the respective participant. Time-series of raw pixel-change were first subjected to automatic detectors for video-noise (i.e. pixel-changes caused by irregularities in the VHS-signal). Corrected time-series were then smoothed with a moving average of 0.4 s, which further reduces fluctuations due to signal-distortion. In order to account for different size regions of interest, data were z-transformed. In a final step, a threshold for minimal movement was calculated for each region of interest separately (Figure 1B). Data filtered and corrected in this manner were submitted for final analyses (for details see Grammer et al., 1999). The objectivity of this kind of automatic movement analysis is high, i.e. MEA is observer-independent once the procedure is established. MEA provided objective and unobtrusive quantitative measures of the *dynamic* movement characteristics displayed by patient and therapist.

Quantification of synchrony

We quantified nonverbal synchrony for the first 15 min of interaction, initiating a 50-min therapy session. Time-series of motion energy (Figure 1B) were cross-correlated (Boker, Xu, Rotondo, & King, 2002) in window segments of one minute duration, taking into consideration the non-stationary nature of movement behaviors. Cross-correlations for positive and negative time-lags up to 5 s in steps of 0.1 s were computed for each window by step-wise shifting one time-series in relation to the other (50 steps in each direction of positive and negative lags). Cross-correlations were then standardized (Fisher's Z) and their absolute values were aggregated over the entire 15-min interval, yielding one global value of nonverbal synchrony (15 min ± 5 s X steps of 0.1 s; n = 1,515, see Figure 2A).

The use of absolute values means that both positive and negative cross-correlations contributed positively to the 15-min synchrony measure. This strategy yields a single value, representative of the global movement coordination between therapist and patient. Due to the Z-transformation of correlation coefficients, this synchrony value follows a bivariate normal distribution. In addition to this global synchrony measure, we were interested in the direction of the imitation: who of the two interactants was acting as the *zeitgeber* (timekeeper, i.e. the interactant who appears to set the pace; Grammer et al., 1998; McGarva & Warner, 2003) for the respective other interactant? Using the same time-lagged cross-correlations as described above, we identified when the therapist was following the patient by a lag of up to 5 s (*pacing*: patient as zeitgeber; negative lags), or when the therapist was followed by the patient (*leading*: therapist as zeitgeber; positive lags). Our usage of pacing and leading resembles that of Bandler and Grinder (1979), but it must be noted, that we use the terms in a descriptive sense only. We do not imply that interactants were consciously leading, pacing, or otherwise mimicking one another.

We limited synchrony quantification to the initial 15 min of therapy because later in the sessions the interaction was frequently interrupted by uses of questionnaires, flip-charts or other non-verbal activity. A pilot study with analyses of whole sessions (n = 20; Ramseyer, 2008) showed that 15-min segments correlated satisfactorily with full 50-min sessions [reliability $r(20) = .70$]. A meta-analysis on the accuracy of ratings of nonverbal behavior (Ambady & Rosenthal, 1992) points in a similar direction, documenting that thin slices of behavior provide sufficiently accurate predictions.

Control for spurious correlations: Pseudosynchrony

A major criticism of studies on nonverbal synchrony concerns the lack of a control for coincidental synchrony (Gatewood & Rosenwein, 1981; Hess et al., 1999; McDowall, 1978) – that is, synchrony caused by random coincidence. Bernieri et al. (1988) worked with so-called pseudointeractions “ ... by isolating the video image of each interactant and then pairing them with the video images of other interactants recorded in other interactions.” (p. 245). Pseudointeractions thus generate ‘face-to-face interactions’ of persons who did not actually interact with each other. Bernieri et al. were able to show significantly higher synchrony in genuine mother-child interactions compared to pseudointeractions. We implemented a similar technique based on this idea: Our pseudointeractions were generated on short time-scales by using automated surrogate testing algorithms (Ramseyer & Tschacher, 2010). Surrogate datasets (n = 100 out of each genuine dataset) were produced by segment-wise (1-min segments) shuffling of the original data, thus aligning patient's and therapist's movement segments that never actually occurred at the same time. This procedure kept the individual progressive time structure (by minute) of data intact. Pseudosynchrony in shuffled datasets was calculated identically to the synchrony of the original data as described above. For the statistical comparison of nonverbal synchrony versus pseudosynchrony, the mean value of surrogate datasets was computed (i.e. the base-level of pseudosynchrony) and compared with the value of genuine synchrony. Each session was thus characterized by one value of genuine nonverbal synchrony and one value of pseudosynchrony.

Measures of therapeutic process

Session reports. Versions of the *Bern Post-Session Report* (Flückiger, Regli, Zwahlen, Hostettler, & Caspar, 2010) were administered to both patient (BPSR-P) and therapist (BPSR-T) independently after each therapy session, as was routinely done in all archived sessions as part of ongoing research activity. These self-report measures comprised 22 (BPSR-P) and 27 (BPSR-T) items loading on five factors determined in previous factor analysis (Tschacher, Ramseyer, & Grawe, 2007). Two factors captured the patient's view of the therapy process: relationship quality (exemplary item, "My therapist and I get along well") and patient's self-efficacy ("I feel more capable of solving my problems"). Three factors reflected the therapist's perspective: relationship quality ("Today, I felt comfortable with the patient"), therapist's mastery interventions ("Today, I have actively worked towards helping the patient to view his problems from a different angle") and therapist's insight interventions ("In this session, I worked towards improving the patient's coping ability in difficult situations"). The remaining two factors of therapist's interventions are reported here for the sake of completeness. We hypothesized that these final two factors represent the working style of therapists and hence do not influence the dyadic relationship in the same manner as the three factors included in the analysis. Internal consistency of BPSR scales range from .75 to .88 as reported by Flückiger et al. (2010). The BPSR parameter details including Cronbach's α are reported in Table 1. Intra-dyad agreement for relationship quality ratings in our data was relatively low (r = .38), consistent with the different assessments of therapeutic relationship by patients and therapists found in a larger dataset (n = 10,834 sessions) at the outpatient clinic of the University of Bern (r = .41).

Measures of therapeutic success

Outcome of therapy was given by retrospective measures of success (patient's evaluation at termination of therapy) as well as pre-to-post change measures of success (comparisons of pre-post assessments). All instruments were based on patient self-reports.

Goal Attainment Scaling (GAS, Cardillo & Smith, 1994) assesses to what extent the individual treatment goals defined at the beginning of therapies were attained. Patients perform these assessments at the end of therapies using a 7-point Likert scale, in which higher scores indicate greater goal attainment. Labels for ratings are based on individually defined treatment goals and the scores used here may range from deterioration (-2: most unfavorable outcome thought likely) to no change (0: less than expected success with treatment) to various levels of improvement (4: best anticipated success with treatment). Cardillo and Smith reported inter-rater reliabilities of .87 and .71 for independent judges. The *Questionnaire to Assess Changes in*

Experiencing and Behavior (VEV, Veränderungsfragebogen des Erlebens und Verhaltens, Zielke & Kopf-Mehnert, 2001) records subjective change by comparative questions regarding positive changes in a person's emotional experiences and behavior since initiation of therapy The measure consists of 27 self-rated items with 7-point scales, of which the two poles are printed (e.g., "Compared with the time prior to initiation of therapy, I feel more relaxed/more tense"). The measure provides a global index of overall improvement. Zielke and Kopf-Mehnert reported an internal consistency of .98 and test-retest reliability of .61 over an 8-week period. The *Inventory of Interpersonal Problems* (IIP, Horowitz, Rosenberg, Baer, Ureño & Villaseñor, 1988) is a measure of current difficulties in interpersonal functioning. Apart from a total score indicative of the overall level of interpersonal problems, eight subscales pertaining to the circumplex model of interpersonal behavior are assessed using a 5-point Likert scale (64 items ranging from 0 to 4; IIP-D, Horowitz, Strauss, & Kordy, 1994). Horowitz et al. (1988) report an internal consistency ranging from .82 to .94 with a 10-week test-retest reliability of .80 to .90. The *Brief Symptom Inventory* (BSI, Franke & Derogatis, 2000) is a measure used to assess general symptom distress. Using a 5-point Likert scale, patients indicate to what extent they experienced each of 53 distress symptoms in the past week. The measure provides a Global Severity Index of overall current symptomatology. Franke and Derogatis reported internal consistencies between .63 and .85 with a test-retest reliability between .73 and .92 over a 1-week period. The *General Self-Efficacy Scale* (GSE, Schwarzer & Jerusalem, 1995) assesses a general sense of perceived self-efficacy with 10 items scored on a 4-point Likert scale. This unidimensional scale predicts coping with daily hassles as well as adaptation after experiencing various kinds of stressful life events. Consistencies from samples of 23 nations (Schwarzer, Mueller, & Greenglass, 1999) ranged from .76 to .90, with the majority in the high .80s. The patients' adult attachment style was measured with the *Measure of Attachment Qualities* (MAQ, Carver, 1997). The 14 items are scored on a 4-point Likert scale ranging from 1 to 4. The measure provides four scales of attachment types: avoidance, ambivalence-worry, ambivalence-merger, and security. We computed one attachment score using the mean of the four individual scales, with positive values representing insecure attachment. Carver reported internal consistencies of .69 to .76 and a test-retest reliability of .61 to .80 over a 6-week period.

Factor analysis of pre-to-post change and retrospective outcome measures (Michalak, Kosfelder, Meyer, & Schulte, 2003) indicates that instruments can be summarized into *pre-to-post* and *retrospective* categories. z-standardized scores were used to calculate one measure of pre-to-post outcome (IIP, BSI, GSE, MAQ) and one of retrospective outcome (GAS, VEV). To calculate pre-to-post outcome, effect sizes were defined for each patient as the difference between pre- and post-therapy values divided by the standard deviation of the archive's (n = 301) pre-values. Positive values of pre-to-post outcome, therefore, indicate improvement in interpersonal behavior, psychopathology, self-efficacy and attachment (pre-post comparison of symptomatology). Positive values of retrospective outcome indicate improvement in patient goals and positive changes in experience and behavior (retrospective evaluation of improvement). Details of individual scales are presented in Table 2.

Data Analysis

Multilevel modeling using SAS PROC MIXED (Littell, Milliken, Stroup, & Wolfinger, 2006) was used as the primary data analytic tool. In comparison to repeated ANOVA's, multilevel models are best suited for the data presented here because they allow missing data (missing at random) of either phase T1 or T3 sessions. The data were structured in three levels as follows: Sessions (Level 1) were nested within patients (Level 2) nested within therapists (Level 3). Models with Level 3 variables (therapists) were assessed. However, due to insignificant variances and for the sake of clarity, these models have been left out of the final models reported here. Fixed effects were ‘phase of therapy’, ‘sex’, ‘diagnosis’, ‘session-report factors’, and ‘outcome measures’. Random effects were ‘intercept’ and ‘patient’. Based on preliminary analyses and in order to limit the number of estimated parameters in our models, we decided to enter only genuine synchrony into models of hypotheses 2 and 3. Several multilevel models were thus constructed to examine synchrony vs. pseudosynchrony (hypothesis 1), the effects of synchrony on session outcome (hypothesis 2) and the effects of synchrony on therapy outcome (hypothesis 3). We identified best fitting models using information criteria (AIC) and variances and covariances of the variables under study according to Singer (1998). Degrees of freedom were calculated using the Satterthwaite method. For hypothesis 1, the raw scores of nonverbal synchrony and pseudosynchrony were used for calculations (mean Fisher’s Z correlations). In addition to mixed models, effect size estimates (Cohen’s *d*) based on dependent *t*-tests are reported for hypothesis 1. Hypotheses 2 and 3 were assessed with a z-transformed synchrony variable: nonverbal synchrony – pseudosynchrony / $SD_{\text{pseudosynchrony}}$, providing an effect-size estimate of nonverbal synchrony compared to pseudosynchrony. This value yields parameter estimates of mixed models that are intuitively interpretable. In the results section, type-3 tests of fixed effects are presented. Additionally, Pearson's *r* for hypotheses 2 and 3 are reported in Tables 1 and 2. All tested multilevel models are displayed in tables reported in the web-appendix (Tables W1 to W4).

Results

Hypothesis 1: The comparison of nonverbal synchrony with pseudosynchrony derived from shuffled data demonstrated that the synchrony phenomenon was present at a level above chance: Across all patients, nonverbal synchrony was significantly higher than pseudosynchrony ($M_{\text{synchrony}} = 0.113$, $SD = 0.017$ vs. $M_{\text{pseudosynchrony}} = 0.106$, $SD = 0.010$), $F(1,137) = 27.70$, $p < .001$. No difference of nonverbal synchrony was found for fixed effects of sex, $F(1,66.9) = 0.26$, $p = .609$, phase of therapy, $F(1,181) = 0.67$, $p = .414$, or diagnostic group $F(2,67.7) = 0.50$, $p = .607$. All interaction effects were nonsignificant and resulted in a poorer fit for these models. The best fit (AIC) was achieved for the direct comparison of synchrony versus pseudosynchrony without further fixed effects specified. The magnitude of the difference between nonverbal synchrony and pseudosynchrony was (Cohen's) $d = 0.59$ in T1 and $d = 0.50$ in T3. Nonverbal synchrony was not associated with symptom severity at intake (IIP_{pre}: $r = -.08$; BSI_{pre}: $r = .07$; GK_{pre}: $r = -.06$; MAQ_{pre}: $r = -.05$; all n.s.).

Hypothesis 2: The three self-report factors assessing relationship quality (patients' and therapists' view) and self-efficacy were entered as fixed effects in multilevel models for hypothesis 2. Fit parameters of all models (see Tables W1 to W4, web-appendix) were very similar. As main effects did not differ in significance, only the best-fitting model (AIC, comparison of Residual variance) is described here. This model included predictors from the BPSR and 'phase of therapy', namely relationship quality (patient perspective, PAT) $F(1,99) = 5.77$, $p = .018$ and self-efficacy (PAT) $F(1,92.4) = 4.24$, $p = .042$. Higher ratings of relationship quality and self-efficacy co-occurred with higher nonverbal synchrony. Therapists' ratings (TH) of relationship quality were unassociated with nonverbal synchrony $F(1,100) = 0.00$, $p = .986$. Synchrony was significantly higher in the initial phase of therapy $F(1,68.2) = 4.09$, $p = .047$.

Correlations of self-report factors corroborated results from mixed models: as detailed in

Table 1, nonverbal synchrony was positively correlated (Pearson's *r*) with patients' evaluations of the quality of the therapeutic relationship in T1 [$r(46) = .326$, $p = .026$] as well as T3 [$r(56) = .328$, $p = .013$] and with patients' reported self-efficacy [T1: $r(46) = .352$, $p = .015$; T3: $r(56) = .257$, $p = .054$]. The correlation with therapists' evaluations of relationship quality, however, was not significant in T1 [$r(46) = .064$, $p = .671$] and only a trend in T3 [$r(56) = .231$, $p = .083$]. As expected according to item content, clarification and insight interventions were not significantly associated with synchrony (all *p*'s > .10). Synchrony scores based on pacing and leading correlations were separately analyzed with mixed models, with the aim of identifying the zeitgeber for nonverbal movement. Pacing was significantly associated with self-efficacy [$F(1,97.5) = 4.35$, $p = .040$], without further fixed effects or interaction effects specified. For leading, a significant association with relationship quality [$F(1,104) = 8.34$, $p = .005$], and phase of therapy [$F(1,104) = 5.75$, $p = .018$] was found. Leading was more pronounced in the initial phase of therapy. Patient's diagnosis showed a trend to be differentially associated with leading [$F(2,104) = 2.62$, $p = .077$], patients with anxiety disorders had lower synchrony in comparison to other diagnostic groups, i.e. patients with anxiety disorders imitated their therapist's movement less. No other fixed effects or interaction effects were significant. In terms of who acted as the zeitgeber, there was no significant difference between absolute amounts (aggregated, mean Fisher's Z) of pacing ($M = 0.112$, $SD = 0.018$) versus leading ($M = 0.113$, $SD = 0.019$).

Hypothesis 3: Mixed models with measures of pre-to-post and retrospective outcome showed that only pre-to-post outcome was significantly associated with nonverbal synchrony [$F(1,68.1) = 6.88$, $p = .011$], indicating that patients with high synchrony had a higher reduction of symptomatology at the end of treatment. Such an effect was not found for retrospective outcome [$F(1,69.8) = 0.10$, $p = .752$]. Correlations of nonverbal synchrony with individual instruments are given in Table 2. The general pattern of pre-to-post measures can be summarized as follows:

Self-reported psychopathology at outcome is lower in dyads manifesting high synchrony, i.e. patients with higher nonverbal synchrony have less distress from interpersonal problems (IIP), show fewer symptoms (BSI), report high self-efficacy (GSE), and indicate less insecure attachment patterns (MAQ). It should be noted here that the outcome of included therapies was generally good, as is reflected in the moderate to large effect sizes of Table 2. Intra-class correlation coefficients (ICC's) for therapists were .08 for nonverbal synchrony, and .05 to .19 for post-session questionnaires. These values indicate that variability in nonverbal synchrony between individual therapists was low and further support our exclusion of 'therapist' as a Level-3 variable in mixed models.

Discussion

The present study explored nonverbal synchrony in dyadic psychotherapy sessions and its associations with session-level process measures and global therapy outcome. Consistent with the first hypothesis, our data show that, in psychotherapeutic interactions, synchrony is found at a level clearly above chance. To our knowledge, this is the first empirical validation of nonverbal synchrony in real psychotherapy sessions with randomized sampling and pseudosynchrony as a control condition. Synchrony was found in both male and female dyads, in all included diagnostic groups, and in initial as well as final phases of therapies. These data do not imply, however, that *all* movement is synchronous, with mean absolute amounts of synchrony of approximately $r = .10$ (mean cross-correlations), signifying that during any 15-min session, intermittent phases of unsynchronized movement were also present (e.g., Fig. 2A). Overall, our data show that nonverbal synchrony commonly accompanies therapeutic interactions, as it does in human social interaction among subjects without psychopathological symptoms: "Copying, at various levels of generality, is thus a default social behavior for normal human adults ..."

(Hurley, 2008, p. 5). It is conceivable that in more severe cases of psychopathology (e.g. severe major depressive episode/acute mania), synchrony could be less evident (Geerts et al., 2006) when nonverbal behavior is more strongly influenced by psychopathology (Kupper et al., 2010). However, in the ambulatory setting described here, nonverbal synchrony is not only a common part of the patient-therapist interaction, it also predicts relationship quality and therapeutic outcome: Our second and third hypotheses extend previous findings in social psychology proposing that synchrony is a nonconscious mechanism promoting relationship quality and task performance in social interaction (Lakin & Chartrand, 2003): We asserted that synchrony was associated with process and outcome measures. The association with good therapeutic rapport corroborated isolated previous findings and is consistent with common wisdom in psychotherapy training and practice, where nonverbal interaction is treated as an important means for the establishment and maintenance of the therapeutic relationship (Philippot et al., 2003). The reported correlations between nonverbal synchrony and interpersonal variables (Table 2) corroborate mixed models on pre-to-post outcome and imply that a core property of therapeutic interaction is reflected in the synchrony measure described here. Relationship behavior, attachment styles, self-efficacy expectations, interpersonal problems – these variables were all related in a meaningful way to our observations of synchrony in the therapy setting. These associations imply that nonverbal synchrony is linked to personal characteristics in the domain of interpersonal behavior. Further experimental research is needed to clarify the mechanisms. For example, anxious individuals may resist closeness initially but over time come to tolerate closeness and exhibit greater synchrony.

The zeitgeber analysis showed that whereas absolute amounts of either pacing or leading did not differ significantly between interactants, associations of pacing and leading had a distinctive pattern. Mixed models revealed that therapist’s pacing was predominantly associated with patient's self-efficacy, while therapist's leading corresponded with patient's relationship rating. Additionally, leading was significantly associated with relationship quality in the initial phase of therapy. Our results indicated that a therapist's leading accompanies a positive relationship whereas a therapist's pacing (i.e. imitating the patient) goes together with a patient's self-efficacy. These specific associations appear to be most important during the initial phase of therapy, corroborating results from previous alliance-outcome research (Martin et al., 2000).

The present study has limitations since, due to their correlational nature, the data presented here do not allow causal inference about whether nonverbal synchrony is the product of a good relationship or a necessary pre-condition. Based on studies in social psychology (see: Chartrand & van Baaren, 2009), it is conceivable that both pathways add to the overall effect: nonverbal synchrony increases relationship quality and vice versa. Experimental studies in the therapeutic context will help to disentangle their relative contributions. Furthermore, the study sample used in the analyses reported here has certain limitations: one being the fact that only same-sex dyads have been considered. This decision was primarily made in order to achieve sufficient power for all conditions assessed (sex of interactant / phase of therapy). It was also based on previous research indicating mixed findings in opposite-sex dyads. The restriction to same-sex dyads obviously limits the generalizability of the findings. However, in our general population only 31% of all psychotherapy pairings were opposite-sex dyads; thus we likely represented the larger portion of psychotherapies conducted in the field. Our selection of sessions included only the initial and final phases of therapy. Future studies should assess synchrony in the middle phase of therapy to investigate synchrony development throughout the therapeutic process. Another limitation is the exclusion of analyzable sessions. A considerable number of video recordings had to be excluded due to technical quality of the tapes or because the interactants moved in the therapy room in a way that MEA was not feasible (Figure W1). There is no obvious relationship, however, between these exclusion criteria and our study objectives. We are therefore confident that exclusion has not resulted in a selection bias with respect to the statistical analyses. A final concern may be the distribution of diagnoses, which reflects the general clientele of an ambulatory therapy setting in a university city with good psychotherapy service provision. It remains unclear whether our findings can be generalized to other settings.

Our findings that the dynamic quality of nonverbal movement is indicative of interpersonal and psychological processes may be viewed in light of the general principle known as 'embodiment' (Gallese, 2005). The processes of relationship development and maintenance are not confined to verbal channels and to facial expression; the bodies of interacting persons reflect properties of their psychological relationship and inner states that become observable (Hall et al., 1995). Embodiment has theoretical implications for psychology and cognitive science, which are currently discussed in the context of embodied cognition. In general, it is becoming acknowledged that mental processes are insufficiently understood in the framework of symbol manipulation and information processing alone (Tschacher & Dauwalder, 2003). Our present findings are consistent with a systems-theory viewpoint (Vallacher & Nowak, 2009) that emphasizes the (self-organized) emergence of higher-order processes that occur when two individuals engage in interaction. A dyadic system with novel properties and potential for development is created in such interactions. At the neuronal level, this theoretical explanation is supported by empirical results of mirror-neuron activity (Iacoboni, 2009). The visual perception of another's motor actions leads to neuronal changes in the perceiver (neuronal resonance), which can in turn influence the perceiver's actions. Such feedback loops likely generate system properties (such as synchrony) that are not present at the level of individual elements (e.g. individual motor action). Nonverbal synchrony may thus play its role as a subtle, evolutionary based signal (Lakin et al., 2003) that embodies important information about the compatibility of a social interaction partner.

For the clinician, nonverbal synchrony may serve as a source of information about central aspects of therapy process. In the present study, we investigated nonverbal synchrony as a nonconscious phenomenon, characterizing a positive therapeutic relationship. One prediction is that a therapist's voluntary creation of synchrony would improve the therapeutic bond as well as the patient's self-efficacy, especially early in treatment. This prediction would be consistent with our process findings, however experimental evidence for such causal links is unavailable.

In conclusion, we believe that the use of MEA and time-lagged cross-correlations establishes a novel method for nonverbal assessment that is suitable for any social encounter where coordinative processes such as nonverbal synchrony occur. This approach offers objective measures that result in insights into nonconscious, embodied aspects of social relationships. Replication of these findings will strengthen our confidence in them, and we encourage further use of MEA in social interactions of dyads or of situations with larger groups of persons involved. MEA offers a theory-free tool that allows a straightforward quantification of body movement in any kind of interaction. Paired with statistical controls for random coincidence, further insight into system-level phenomena such as synchrony can be expected. MEA enables quantifying nonverbal behavior in a wide range of video recordings and is suitable for analyzing individual movement (Grammer et al., 1997; Kupper et al., 2010) as well as assessing dyadic synchrony. Given today's high availability and affordability of video recordings, MEA-based methodology could help bridge the gap between qualitative and quantitative research of nonverbal behavior.

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Table 1. Means, Standard Deviations and Intercorrelations of Process Variables Reported by Patients (PAT) and Therapists (TH). Diagonal: *α* Reliability Estimates (Cronbach's *α*). Associations (Pearson's *r*) with Nonverbal Synchrony for Initial Third of Therapy (T1; $n = 47$) and Final Third of Therapy (T3; $n = 57$).

Variable	*M*	*SD*	Correlations 1	2	3	4	5	Associations (*r*) synchrony T1	synchrony T3
1 Relationship Quality PAT	1.97	0.60	(.88)					.33*	.33*
2 Self-Efficacy PAT	1.19	0.93	.42	(.90)				.35*	.26[t]
3 Relationship Quality TH	1.51	0.62	.38	.30	(.82)			.06	.23[t]
4 Insight TH	0.16	1.14	-.04	.12	-.02	(.87)		.21	-.20
5 Mastery TH	0.17	1.28	.04	.34	.12	.01	(.82)	-.12	-.05

[t] $p < .10$; * $p < .05$

Table 2. Pretreatment, Posttreatment, Means, Effect Sizes (Cohen's *d*), and Reliability (Cronbach's *α*) of Outcome Assessments. Correlations (Person's *r*) of Synchrony with Posttreatment Scores Computed for the Initial Third (T1; *n* = 45 - 47) and Final Third (T3; *n* = 52 - 56) of Therapies.

	Pre-to-Post Change				Pre-to-Post Outcome	Retrospective Evaluation		Retrospective Outcome
Time of measurement	IIP *M* (*SD*)	BSI *M* (*SD*)	GSE *M* (*SD*)	MAQ *M* (*SD*)	*M* (*SD*)	GAS *M* (*SD*)	VEV *M* (*SD*)	*M* (*SD*)
Pretreatment score	12.44 (3.27)	1.07 (0.61)	24.46 (5.14)	0.75 (0.40)		–	–	
Posttreatment score	9.39 (4.06)	0.45 (0.38)	28.66 (4.91)	0.50 (0.46)		2.73 (1.03)	153.08[a] (21.63)	
Cronbach's *α* (Posttreatment score)	.87	.90	.88	.72	.63	.91	.75	.70
Cohen's *d* (pretreatment-posttreatment)	0.75	1.02	0.77	0.53	0.76 (0.69)	–	–	2.65 (1.00)
Pearson's *r* (synchrony X posttreatment)	T1: -.35* T3: -.25[t]	T1: -.29[t] T3: -.11	T1: .41** T3: .31*	T1: -.27[t] T3: -.35**		T1: .27[t] T3: .20	T1: .28[t] T3: .16	
Pearson's *r* (synchrony X *d*)	T1: .35* T3: .24[t]	T1: .35* T3: -.03	T1: .27[t] T3: .27*	T1: .25[t] T3: .16	T1: .45** T3: .24[t]	–	–	T1: .32* T3: .20

[t] $p < .10$; * $p < .05$; ** $p < .01$

[a] A value of 108 designates no improvement; higher values mean better improvement

IIP, Inventory of Interpersonal Problems; BSI, Brief Symptom Inventory; GSE, General Self-Efficacy Scale; MAQ, Measure of Attachment Qualities; GAS, Goal Attainment Scaling; VEV, Questionnaire to Assess Changes in Experiencing and Behavior; Pre-to-Post Outcome: Mean of IIP, BSI, GSE, MAQ z-scores; Retrospective Outcome: Mean of GAS, VEV z-scores.

Figure 1

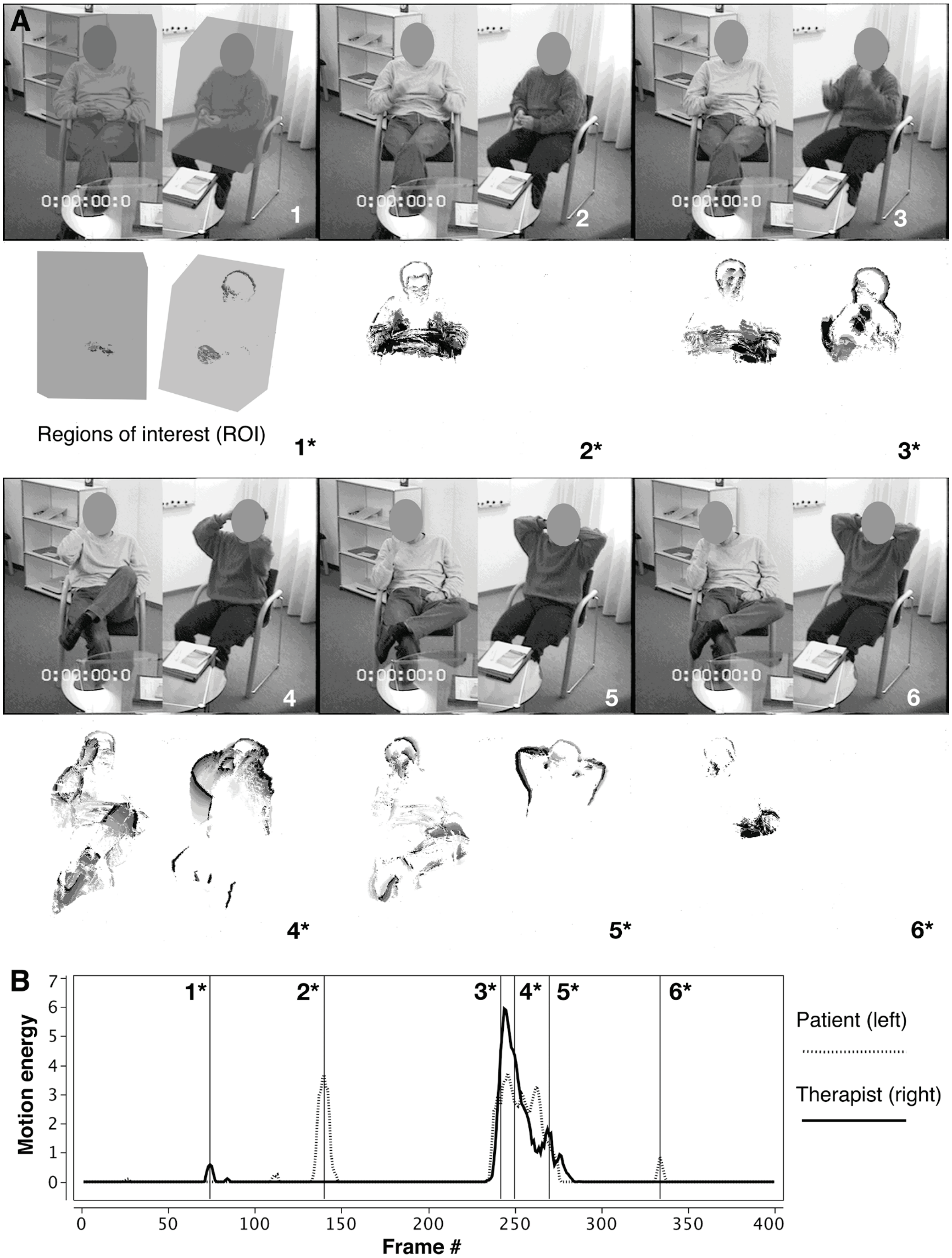
A
0:00:00:0
1
2
3
Regions of interest (ROI)
1*
2*
3*
4
5
6
4*
5*
6*
B
Motion energy
Frame #
Patient (left)
Therapist (right)

Figure 2

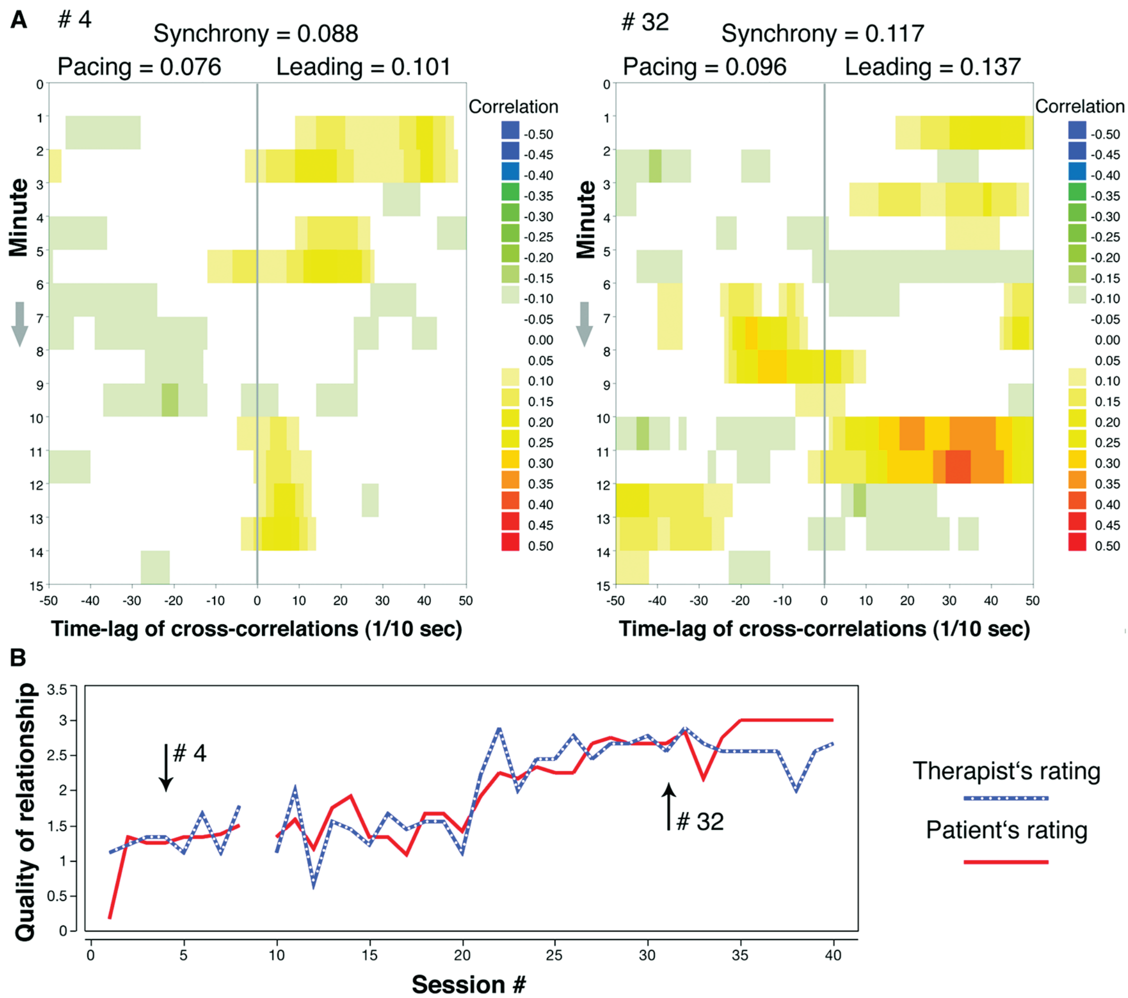
A
# 4
Synchrony = 0.088
Pacing = 0.076
Leading = 0.101
# 32
Synchrony = 0.117
Pacing = 0.096
Leading = 0.137
Correlation
Minute
Time-lag of cross-correlations (1/10 sec)
B
Quality of relationship
Session #
4
32
Therapist's rating
Patient's rating

Figure 1. Motion energy analysis (**A**) Stills (1-6) taken from the original sequence of videotaped interactions between patient (left) and therapist (right). Corresponding images (1'-6') of motion energy are shown below stills. Motion energy was calculated in predefined regions of interest covering the upper body beginning at the base of the chairs. (**B**) Time-series of individual motion energies (smoothed, z-standardized and threshold-adjusted). Position of stills are indicated by vertical lines. Frames 3 to 5 (1A) show an example of movement synchrony between patient and therapist. Only the dynamic aspect of coordinated movement was assessed with MEA, i.e. the covariation of motion energy time-series depicted in Figure 1B.

Figure 2. Plots of cross-correlations between patient's and therapist's motion energy (**A**) Left, session #4; right, session #32, taken from the psychotherapy of one patient. Ordinate, minute into the session; abscissa, time-lag. Positive correlations are color-coded yellow to red, negative correlations green to blue. Cross-correlations were calculated in separate windows of one-minute duration and with time-lags of ±5 s. (**B**) Time-series of assessments of relationship quality as indicated by patient and therapist using the Bern Post-Session Reports (BPSR) administered after each session. Low ratings indicate lower relationship quality. Broken lines indicate missing data. Arrows indicate sessions of cross-correlation plots.

Figure 2 visualizes the cross-correlations of an exemplary single case. The role of zeitgeber can be found on the right side of the central division line of each of the displays in the Figure. Cross-correlations with negative lags (-5 s to 0 s) represent *pacing*, whereas positive lags (0 s to +5 s) stand for *leading*. In this example, the therapist acted as zeitgeber in session #32, leading the patient in minute 11 by a lag of roughly 3 s (c.f. the red area of the plot).

Appendix for Motion Energy Analysis (MEA).

MEA was programmed in MAX/MSP 4.5 ®, an interactive graphical programming environment for music, audio, and media by cycling'74 (www.cycling74.com). MEA is using the plugin softVNS 2.17 by David Rokeby (www.softVNS.com). The implementation described in this paper was customized to output numerical time-series of change in pre-defined regions of interest (Ramseyer, 2008). More information on MEA and a demonstration movie can be obtained from the first author by email (ramseyer@spk.unibe.ch).

Web-Appendix

Figure W1

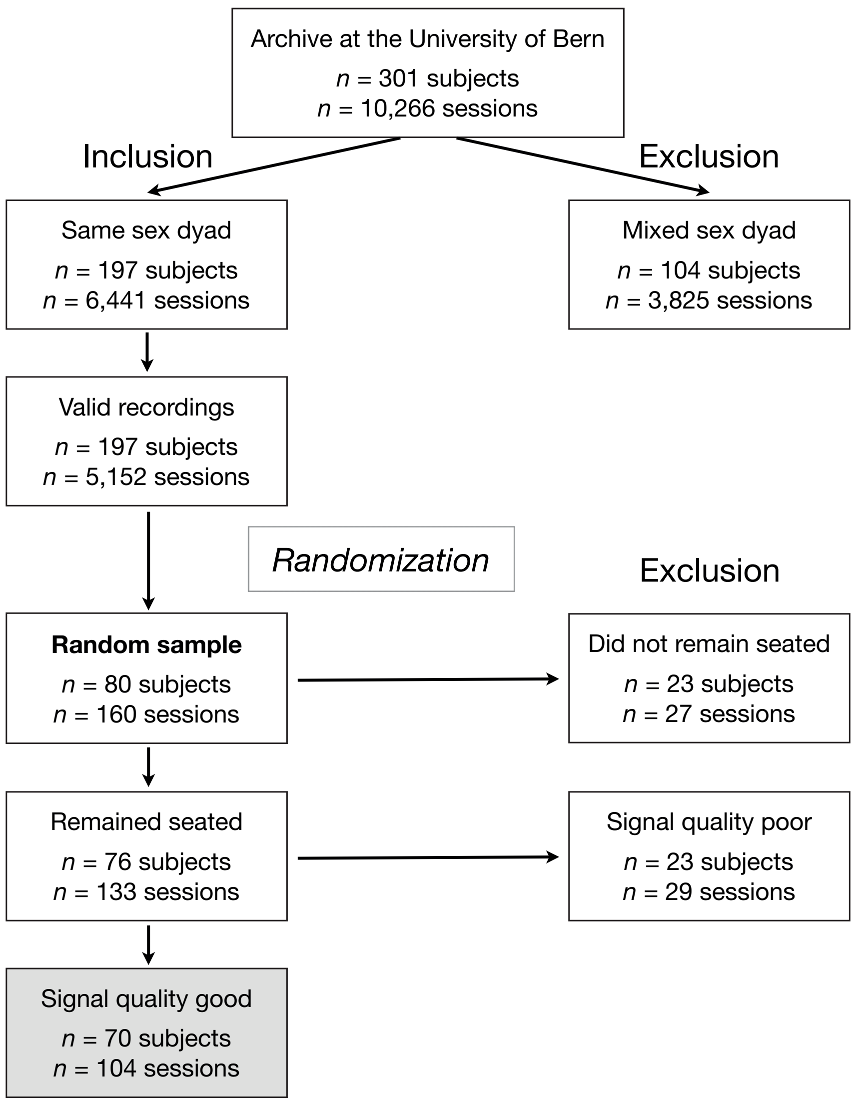

Figure W1. Flow chart of session randomization and selection criteria.

Table W1. Parameter Estimates (and Standard Errors) for Mixed Effects Models Examining the Difference Between Synchrony and Pseudosynchrony and the Effects of Patient Variables (Phase, Gender, Diagnostic Group).

	Hypothesis 1				
Fixed Effects	Model 1	Model 2	Model 3	Model 4	Model 5
Intercept	0.1123*** (0.0015)	0.1117*** (0.0017)	0.1116*** (0.0021)	0.1105*** (0.0024)	0.1091*** (0.0028)
Synchrony: (Genuine; Pseudo = 0)	0.0079*** (0.0015)	0.0079*** (0.0015)	0.0079*** (0.0015)	0.0079*** (0.0015)	0.0079*** (0.0015)
Phase: (T1; T3 = 0)		0.0014 (0.0017)			0.0015 (0.0017)
Sex: (Female; Male = 0)			0.0014 (0.0027)		0.0012 (0.0027)
Diagnostic Group: (Affective; Other; Anxiety = 0)				0.0031 (0.0033) Affective	0.0031 (0.0033) Affective
				0.0025 (0.0032) Other	0.0027 (0.0032) Other
Variance Components					
Residual Variance	0.00012***	0.00012***	0.00012***	0.00012***	2.0474***
Patient Variance	0.00008***	0.00008	0.00008***	0.00008	0.0995
AIC	-1206.9	-1205.6	-1205.2	-1204.0	-1217.0

^{t} $p < .10$; * $p < .05$; ** $p < .01$

Table W2. Parameter Estimates (and Standard Errors) for Mixed Effects Models Examining the Associations Between Synchrony, Patient Variables (Phase, Gender, Diagnostic Group) and Process Variables (BPSR-P/T).

	Hypothesis 2					
Fixed Effects	unconditional means model	Model 6	Model 7	Model 8	Model 9	Model 10
Intercept	0.6457*** (0.1659)	0.6568*** (0.1487)	0.3773[t] (0.2010)	0.6345** (0.2113)	0.4283[t] (0.2547)	0.0813 (0.3201)
Relationship Quality PAT†		0.5956* (0.2997)	0.7229* (0.3009)	0.5986* (0.3004)	0.5608[t] (0.2995)	0.6881* (0.3001)
Self-Efficacy PAT†		0.3190[t] (0.1800)	0.3672* (0.1782)	0.3155[t] (0.1816)	0.3441[t] (0.1822)	0.3983* (0.1819)
Relationship Quality TH†		-0.0054 (0.2619)	-0.0046 (0.2570)	-0.0117 (0.2654)	0.02246 (0.2644)	0.0379 (0.2625)
Phase: (T1; T3 = 0)			0.6187* (0.3060)			0.6611* (0.3033)
Sex: (Female; Male = 0)				0.0455 (0.3057)		-0.0180 (0.3033)
Diagnostic Group: (Affective; Other; Anxiety = 0)					0.4461 (0.3794) Affective	0.5172 (0.3773) Affective
					0.2674 (0.3586) Other	0.3681 (0.3559) Other
Variance Components						
Residual Variance	2.0825***	2.2341***	2.1444***	2.2333***	2.1547***	2.0474***
Patient Variance	0.4838	0.0401	0.0438	0.0404	0.0899	0.0995
AIC	397.9	392.6	390.6	394.6	395.2	394.5

[t] $p < .10$; * $p < .05$; ** $p < .01$

† Process measures were centered at their grand mean, allowing easier interpretation of intercepts

Table W3. Parameter Estimates (and Standard Errors) for Mixed Effects Models Examining the Associations Between pacing/leading, Patient Variables (Phase, Gender, Diagnostic Group) and Process Variables (BPSR-P/T).

	Hypothesis 2 / pacing – leading			
Fixed Effects	pacing 1	leading 1	pacing 2	leading2
Intercept	0.7824*** (0.1777)	0.6225*** (0.1477)	0.5072 (0.3810)	-0.1932 (0.3098)
Relationship Quality PAT†	0.3075 (0.3467)	0.7101* (0.2990)	0.4055 (0.3532)	0.8191** (0.2919)
Self-Efficacy PAT†	0.4375* (0.2098)	0.1504 (0.1794)	0.5015* (0.2149)	0.2353 (0.1766)
Relationship Quality TH†	0.05475 (0.3031)	-0.0382 (0.2612)	0.0656 (0.3085)	0.0406 (0.2557)
Phase: (T1; T3 = 0)			0.4534 (0.3471)	0.8149** (0.300)
Sex: (Female; Male = 0)			-0.0681 (0.3639)	-0.0148 (0.2921)
Diagnostic Group: (Affective; Other; Anxiety = 0)			0.2779 (0.4517) Affective	0.7095^{t} (0.3638) Affective
			0.0719 (0.4280) Other	0.6844* (0.3422) Other
Variance Components				
Residual Variance	2.6457***	2.2686***	2.5854***	2.0450***
Patient Variance	0.0890	0	0.3764	0
AIC	421.5	390.3	427.5	387.5

^{t} $p < .10$; * $p < .05$; ** $p < .01$

† Process measures were centered at their grand mean, allowing easier interpretation of intercepts

Table W4. Parameter Estimates (and Standard Errors) for Mixed Effects Models Examining the Associations Between Synchrony, Patient Variables (Phase, Gender, Diagnostic Group), and Outcome Variables (Retrospective/Pre-to-Post).

	Hypothesis 3				
Fixed Effects	Model 11	Model 12	Model 13	Model 14	Model 15
Intercept	0.6698*** (0.1531)	0.6096** (0.2048)	0.6207** (0.2186)	0.5379* (0.2610)	0.4032 (0.3413)
Retrospective Outcome	0.0605 (0.2118)	0.0734 (0.2125)	0.0689 (0.2122)	0.0626 (0.2155)	0.0698 (0.2159)
Pre-to-Post Outcome	0.8058* (0.3065)	0.7882* (0.3094)	0.7995* (0.3076)	0.7957* (0.3117)	0.7696* (0.3146)
Phase: (T1; T3 = 0)		0.1321 (0.2988)			0.1689 (0.3004)
Sex: (Female; Male = 0)			0.0964 (0.3069)		0.0903 (0.3101)
Diagnostic Group: (Affective; Other; Anxiety = 0)				0.1741 (0.3942) Affective	0.1804 (0.3988) Affective
				0.2222 (0.3630) Other	0.2489 (0.3682) Other
Variance Components					
Residual Variance	2.1748***	2.1597***	2.1654***	2.1467***	2.1177***
Patient Variance	0.1168	0.1281	0.1241	0.1368	0.1580
AIC	380.3	382.1	382.2	383.9	387.5

^{t} $p < .10$; * $p < .05$; ** $p < .01$

WEB-Appendix for Mixed-Model analysis

The variables ‘session report factors’ and ‘outcome measures’ were centered at their grand mean, providing more readily interpretable intercepts for models of hypothesis 2 and 3. The notation of equations used here follow the single level representation used in PROC MIXED.

Random effects entered into all models were ‘intercept’ and ‘patient’.

To illustrate, the basic equations used for hypotheses were as follows:

Hypothesis 1:

2-Level-Model (Overall Mixed Model):

$$\text{SYNCHRONY}_{ij} = \beta_0 + \beta_1 \times \text{SEX}_{ij} + \beta_2 \times \text{DIAGNOSIS}_{ij} + \beta_3 \times \text{PHASE}_{ij} + \beta_4 \times \text{TYPE OF SYNCHRONY}_{ij} + u_j + \varepsilon_{ij}$$

SYNCHRONY_{ij} represents the value of the dependent variable for session *i* in patient *j*; β_0 through β_4 represent the fixed intercept and the fixed effects of the covariates (e.g., SEX, …, PHASE); u_j is the random effect associated with the intercept for patient *j*; and ε_{ij} represents the residual.

Hypothesis 2:

2-Level-Model (Overall Mixed Model):

$$\text{SYNCHRONY}_{ij} = \beta_0 + \beta_1 \times \text{SEX}_{ij} + \beta_2 \times \text{DIAGNOSIS}_{ij} + \beta_3 \times \text{PHASE}_{ij} + \beta_4 \times \text{PROCESS\_MEASURES}_{ij} + u_j + \varepsilon_{ij}$$

Hypothesis 3:

2-Level-Model (Overall Mixed Model):

$$\text{SYNCHRONY}_{ij} = \beta_0 + \beta_1 \times \text{SEX}_{ij} + \beta_2 \times \text{DIAGNOSIS}_{ij} + \beta_3 \times \text{PHASE}_{ij} + \beta_4 \times \text{OUTCOME\_MEASURES}_{ij} + u_j + \varepsilon_{ij}$$