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The melody of ruptures: identifying ruptures through acoustic markers

Tohar Dolev-Amit*, Aviv Nof *, Amal Asaad, Amit Tchizick and Sigal Zilcha-Mano

Department of Psychology, University of Haifa, Haifa, Israel

ABSTRACT

Ruptures in the alliance have a potential to either undermine the treatment, leading to its premature termination, or to enhance it, leading to its success. Detecting ruptures is a critical step in therapy, especially concerning withdrawal ruptures that often go unnoticed because of the indirect expression of negative emotions. The present study explored whether acoustic data of a particular patient can serve as markers for ruptures, particularly withdrawal ruptures. Given the pioneering nature of the study, an exploratory approach based on a case study was chosen. The case-study showed that acoustic data can serve as markers of withdrawal ruptures (characterized by higher F0-span, pause proportion, and shimmer, and lower articulation rate than neutral speech) and of confrontation ruptures (characterized by higher F0-span and pause proportion than neutral speech). The limitations of a case study design are discussed. These findings add to previous knowledge and help to open the door to using feedback to assist clinicians in identifying the occurrence of ruptures and prevent deterioration in alliance and dropout.

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Therapeutic Relationship; alliance; ruptures; acoustic markers; F0

Practical implications

- The current study emphasizes the importance of acoustic data in identifying ruptures, which is a critical phase in resolving them.
- Withdrawal ruptures, that may go unnoticed by therapists, can be identified by their acoustic markers.
- These findings open the door to using feedback on rupture occurrence and training procedures to assist clinicians in identifying them, and consequently in preventing alliance deterioration and dropout.

The therapeutic alliance has received an abundance of empirical and clinical attention, and has been found to be one of the most consistent predictors of treatment outcome (Flückiger, Del Re, Wampold, & Horvath, 2018). The literature generally agrees that the alliance reflects the emotional bond between patient and therapist, and the agreement and collaboration between them on the tasks and goals of treatment. Recently there has been a shift in alliance research, which has started looking into the ways in which alliance

CONTACT Sigal Zilcha-Mano  sigalzil@gmail.com

*These authors contributed equally to this study.

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affects outcome by understanding the in-session processes, focusing, among others, on the rupture resolution process (Safran & Muran, 2000).

A rupture is defined as deterioration or tension in the alliance (Safran & Muran, 2000). It manifests as a break in therapy or a minor tension between patient and therapist in the components of the alliance (Eubanks, Muran, & Safran, 2015; Safran & Muran, 2000). Ruptures are a common part of treatment, and when resolved, are significantly associated with better treatment outcome (for a meta-analysis, see Eubanks, Muran, & Safran, 2018a). Identifying ruptures is a critical stage in reaching resolution (Safran & Muran, 2000), and can lead to effective resolutions and a favorable outcome (Eubanks et al., 2018a). By contrast, unnoticed and unresolved ruptures can lead to deterioration of the alliance and dropout (Eubanks, Lubitz, Muran, & Safran, 2018b). Given the importance and prevalence of ruptures, it is important to know how to identify them.

Ruptures can be categorized into two main types: withdrawal and confrontation (Eubanks et al., 2015; Safran & Muran, 2000). In withdrawal ruptures, patients either move away from the therapist and the treatment in a submissive manner, or move toward the therapist in a way that denies an aspect of the patient's experience. For example, in a withdrawal rupture, a patient may respond to an interpretation by saying "Maybe," followed by a long silence. In confrontation ruptures, patients move against the therapist or the work of therapy and express anger (Eubanks et al., 2018b; Safran & Muran, 2000). For example, in response to a supportive intervention by the therapist, saying "It sounds difficult," the patient reacts with a confrontative response by saying in a hostile tone: "It's not difficult at all, you didn't understand a thing."

There are different ways of assessing alliance ruptures. One of the commonly used methods involves the use of self-report measures, such as the Working Alliance Inventory, WAI (Horvath & Greenberg, 1989). Initially, the WAI has been used to measure the strength of alliance, but in recent years it has been commonly used to measure alliance ruptures by identifying salient declines in the alliance level from one session to the next. Self-report measures of the alliance are quick and inexpensive, but have several limitations: one is that patients and therapists report only what they are aware of and are able to describe at the end of the session; another is that withdrawal ruptures, which are commonly missed by both patients and therapists, have negative effects on treatment outcome (Eubanks et al., 2018b).

Comprehensive observer-based measures of alliance ruptures have been developed to improve the disadvantages of self-report measures, as for example, the Rupture Resolution Rating System, 3RS (Eubanks et al., 2015). Behavioral coding systems are an important and valuable tool in psychotherapy research, capable of revealing important knowledge that is most likely missed by self-report measures (Eubanks et al., 2015). This is especially the case for withdrawal ruptures that can be detected by coding systems but are commonly overlooked in self-reports (Eubanks et al., 2018b). The coding systems, however, also have some limitations, especially a long time required for the intensive training to achieve valid and reliable coding, and the time-consuming coding process.

Given the need to efficiently detect alliance ruptures with minimum reliance on observers, there has been growing interest in advanced technologies and methodologies that optimize automation. There has been some empirical research looking into time-efficient, less labor-intensive assessment approaches to complement rupture coding and self-report measures. Several attempts have been made lately in psychotherapy research

to identify markers for diagnosing and predicting the strength of alliance and of alliance ruptures. For example, one study that focused directly on alliance rupture found that a larger increase in oxytocin levels during the session was associated with more instances of conflicts and ruptures in the alliance with the therapist (Zilcha-Mano, Porat, Dolev, & Shamay-Tsoory, 2018).

In the present study, we propose that acoustic markers are a promising way of detecting alliance ruptures. Acoustic markers were found to be instrumental in identifying a variety of clinical measures, as they can be measured inexpensively, remotely, non-invasively, and non-intrusively. Acoustic markers are vocal and speech parameters that quantify the physical or temporal features of the sound wave and of speech production (Rochman & Amir, 2013). Several fields of science, such as linguistics and voice disorders research, have investigated acoustic markers and found them to be instrumental in identifying medical states.

In psychotherapy research, acoustic markers have been linked to several emotional and process constructs. Although not focusing directly on alliance ruptures, a study by Reich, Berman, Dale, and Levitt (2014) reported that higher levels of corresponding measures of pitch between patients and therapists were related to poorer therapeutic alliance. Theoretically, we can expect ruptures in the alliance to be non-verbally and acoustically communicated to signal a conflict. Empirical evidence has shown that acoustic markers, such as fundamental frequency (F0) and articulation rate, are associated with anger (Rochman, Diamond, & Amir, 2008). The processes of vocally signaling a conflictual social interaction is further supported by evolutionary explanations. Emotional prosody, the music of speech that serves as a medium for expressing emotions, is a feature that humans share with nonhuman primates and more distant ancestors, such as songbirds, and may be considered as an adaptive channel to signal conflictual exchanges as well as ruptures in the alliance. To ensure that listeners understand their intentions, speakers strategically change their vocal cues and prosody (Mauchand, Vergis & Pell, 2020). Prosody is often considered a prime carrier of affective information about states (Scherer, Johnstone, & Klasmeyer, 2003), as well as a carrier of social engagement intentions (Porges, 1995, 2018).

The current study explores the association between alliance and acoustic marker changes. The association between vocal expression and social engagement has been suggested in the polyvagal theory (Porges, 1995). In the course of evolution, humans developed the ability to produce emotional expressions, including vocalizations. Emotional and vocal expressions constitute a social connection medium that enabled better adaptation to environmental demands and to challenges in social interactions. According to the polyvagal theory, their phylogenetic heritage equipped humans with an innate ability to regulate the autonomic nervous system to support the reciprocity of face-to-face social interactions with vocalization as a central medium of communication (Flores & Porges, 2017). When the environment is perceived as safe, several bodily and behavioral changes occur, such as cardiac changes that slow the heart and inhibit fight and flight reactions. These physiological changes also include an influence over laryngeal and pharyngeal muscles that are part of the vocalization production system (Porges, 1995).

The social engagement system includes a neural link that activates physiological states and several reactions, such as intonation changes, which has been referred to as face-heart connection (Flores & Porges, 2017; Porges, 1995). Therefore, it has been suggested

that face–heart connection enables an individual to signal others about their social intentions via both facial expression and vocal intonation (Porges, 1995, 2018).

In the current study, we employed several of the most recommended acoustic markers for use in psychotherapy research: F0-span (the degree of monotonic speech vs. open, wide, and lively speech), pause proportion (silences), articulation rate (the pace at which speech segments are produced), and shimmer and jitter (unsteady and trembling voice quality).

The Fundamental frequency (F0) is subjectively perceived by listeners as the pitch of the sound (De Cheveigné & Kawahara, 2002) and it is defined as the lowest periodic cycle in the acoustic waveform (Juslin & Laukka, 2003). It is a measure of the vibratory rate of the speaker's vocal folds during phonation (Rochman & Amir, 2013). The F0-span measures the changes or span in the voice throughout an utterance, and reflects the extent to which the intonation is restricted, perceived as monotonic speech, or widely varied across the frequency spectrum, perceived as lively and playful speech (Knowles & Little, 2016).

Pauses are silent speech intervals during speech and acoustically are considered as a disfluency variable (MacGregor, Corley, & Donaldson, 2010). Articulation rate quantifies the production rate in fluent speech, while excluding disfluencies, such as pausing segments (Amir & Grinfeld, 2011; Hall, Amir, & Yairi, 1999). Jitter is defined as frequency-perturbation measures that capture “micro” variations in F0, measured between successive voicing cycles (Rochman & Amir, 2013). Jitter is originated by opening and closing the vocal folds from one vocal cycle to the next (Juslin & Laukka, 2003). Shimmer, known as amplitude perturbation, measures the variation from cycle to cycle within the signal amplitude (Rochman & Amir, 2013). Both jitter and shimmer are considered as voice quality acoustic measures (Rochman & Amir, 2013) which also appear to relate to perceived “roughness” and “hoarseness” of the voice (Dejonckere et al., 1996). Regarding a withdrawn therapeutic stance, previous findings have shown that two acoustic markers are associated with states of moving away from the therapist by hesitating and showing disengagement. A slow articulation rate has been shown to reflect hesitations (Watanabe & Rose, 2012), and suggested, in psychotherapy settings, as a sign of inward contemplation and focusing efforts (Rice & Wagstaff, 1967). High levels of pauses, particularly while disengaging from emotions or from the therapy process, indicate poorer treatment alliance (Levitt, 2001). We hypothesized, therefore, that withdrawal ruptures are associated with a slow articulation rate and a high level of pauses.

Regarding a confrontation therapeutic stance, previous findings have shown that three acoustic markers are associated with states of overtly moving against the therapist. A high F0-span was found to be a valid marker of a challenging-confronting therapeutic attitude (Weiste & Peräkylä, 2014). Rochman et al. (2008) have shown that high levels of F0-span and a high articulation rate were associated with anger in psychotherapy settings, whereas high jitter levels were found to characterize expression of anger that followed a sad experience. Shimmer was not found to reflect anger (Rochman et al., 2008). Therefore, we hypothesized that confrontation ruptures are associated with high F0-span, jitter, and articulation rate, and not with shimmer.

Our aim in the current study was to identify ruptures based on acoustic markers. Given that no study to date has examined this relationship, we chose a single case study design, which is well suited to novel research directions and methodologies. Given that this is a new phenomenon, we wanted to examine the relationship using a case-study design,

which also allows us to demonstrate the richness of the clinical encounter and integrate data from different sources. Because the acoustic markers domain comes from a different discipline, we believe that a case study design can help in this interdisciplinary integration with a vivid demonstration of these phenomena. Therefore, the case study design can increase the potential for crossover between modalities (acoustic, ruptures coding, content analysis). This choice is also supported by previous literature indicating that a case study approach is well suited to examine novel research methodologies (e.g., Daniels & Loades, 2017) in the early stages of scientific investigation, such as in the current study.

In addition, some previously published case studies in the literature integrated several different data sources to present a thorough understanding of therapeutic dynamics (Kazdin, 1981; mentioned also in Knox, Hill, Hess, & Crook-Lyon, 2008). According to Knox et al. (2008), case studies offer a research strategy that fosters the investigation of the subtlety and complexity of psychotherapy. Furthermore, Messer (2011) emphasized that case studies can lead to a focus on actual cases in practice, which can aid therapists in integrating theories that are clinically oriented and relevant to them.

To identify acoustic markers of ruptures, we focused on the speech turns of the patient during sessions 2, 4, 8, and 16. We compared speech turns of withdrawal and confrontation ruptures with those of neutral speech turns, which did not include ruptures.

Method

The present study is part of an ongoing randomized controlled trial (RCT) involving supportive-expressive therapy (SET) for depression. All participants met inclusion and exclusion criteria before starting treatment (Zilcha-Mano, Dolev, Leibovich, & Barber, 2018). All participants provided informed consent before participating in the study, including agreeing to all treatment sessions being recorded.

Patient and therapist

The patient was a male in his early thirties, married and working as an engineer. He started therapy with severe depression (Hamilton Rating Scale for Depression, Hamilton, 1967; HRSD = 29) and presenting problems of social isolation and high self-criticism.

The therapist was a male clinical psychologist in his late forties, with 20 years of experience. He underwent 20 hours of training in SE techniques and achieved a sufficient adherence level in two pilot treatments to move into the trial phase. He received weekly personal and group supervision provided by two experienced licensed clinical psychologists, who themselves received supervision from an international SE expert.

Treatment

In this RCT, participants received SET, a manual-based treatment (Luborsky, Mark, Hole, Popp, & Goldsmith, 1995), in 16 individual weekly sessions. SET includes both supportive elements, such as enhancing the alliance and emphasizing adaptive aspects, and expressive elements designed to work on the patient's Core Conflictual Relationship Theme (CCRT; Luborsky et al., 1995). It is based on conceptualizing and working through the patients' CCRT, which includes their main wish (W) in the context of an interpersonal

relationship, an actual or anticipated subjective response from the other (RO) in relation to the W, and the subsequent emotional and behavioral response of the self (RS) to the RO.

Measures

Behavioral coding

We used the Rupture Resolution Rating System (3RS; Eubanks et al., 2015) to assess the ruptures. This is an observational system for coding rupture markers and resolution. Coders watch recorded video sessions and detect events of lack of collaboration or tension between patient and therapist. Identified ruptures are coded as a Confrontation (CF) or Withdrawal (WD), and clarity is rated as a check minus (a weak or somewhat unclear example of the marker), a check (a solid example of the marker), or a check plus (a very clear, “textbook” example of the marker). All coders received 6 months of training (approximately 100 hours) from an experienced coder. During the coding phase, all coders received weekly supervision to maintain reliability. Only ruptures coded as check or check plus were chosen for the analysis. Each session was coded by two experienced coders, blind to the study hypothesis. Inter-rater reliability (ICC) for confrontation ruptures in the current study was .96, and for withdrawal ruptures .98.

F0-span

The F0-span marker captures the amount of within-utterance F0 variation. F0 was extracted using the Praat software package, version 6.1.09 (Boersma & Weenink, 2020), with a manual fixing of false outliers. The F0-span was transformed into a logarithmic scale, the preferred procedure for preventing normality violation biases.

Pause proportion

Before extracting the pause proportion marker, we applied a noise reduction filter. Pauses were extracted automatically by the Praat software, and checked by a trained research assistant to correct errors.

Articulation rate

Based on previous studies, the articulation rate was defined and calculated as the number of syllables or words during the speech turn, excluding the pause segments.

Shimmer and jitter

Shimmer and jitter were extracted using the Praat software as the average absolute difference between consecutive periods of F0 (jitter-local absolute) and of amplitudes (shimmer: dda).

Procedure

To identify ruptures, we first coded sessions 2, 4, 8, and 16 using the 3RS. Two experienced coders in 3RS searched for non-ruptures, that is, neutral content speech turns. Neutral content was characterized as lacking emotion that stands out within the speech turn. In the same sessions coded for ruptures, coders identified 15 neutral speech turns. To validate that these were indeed neutral speech turns, the 15 neutral speech turns and

15 randomly selected rupture speech turns were rated. Four experienced 3RS coders blindly rated the 30 speech turns on a scale of 1 (the speech turn fits poorly in an emotional or rupture context) to 10 (the speech turn fits well in an emotional or rupture context). Inter-rater reliability (ICC) for neutral speech turns was .82 (range 1–3). Speech turns with a rating higher than 3 were removed, leaving 11 neutral speech-turns.

To meet the high standards of audio recording in psychotherapy (Rochman & Amir, 2013), the recordings were performed with a Zoom H5 digital audio recorder using a 44.1 KHz sampling rate, 16-bit, and output as .wav files. The audio files were trimmed and normalized using the Audacity software, open-source audio editing software version 2.0.2 (Ash et al., 1991). Finally, each file (i.e., speech turn) was acoustically analyzed using the Praat software, ver. 6.1.09 (Boersma & Weenink, 2020). Praat software is based on several algorithms that measure acoustic parameters of the voice. The accuracy of Praat software has been assessed in several studies. Boersma (1993) showed that Praat algorithms for measuring acoustic data of F0 and noise to harmony are more accurate and reliable than other methods commonly used for speech presented in the literature. Regarding jitter accuracy, Boersma (2009) indicated that Pratt's jitter algorithm is robust against additive noise and, therefore, it enhances its accuracy. Amir, Wolf, & Amir (2009) have shown that similar mean fundamental-frequency (mF0) values were obtained using both Praat and another program, MDVP. However, the values of jitter and shimmer were different in each application (Amir et al., 2009). The accuracy of Praat has also been supported in previous studies about voice disorders. It has been shown that data obtained from Praat software can differentiate normal voice from pathological voices with parallel accuracy and reliability compared to other common speech analysis software (e.g., Oguz et al., 2007; Sauder, Bretl & Eadie, 2017).

Data analysis

To examine whether acoustic data can serve as markers for ruptures, we conducted statistical and content analysis on the same case. For the statistical analysis, to examine whether any of the dependent acoustic measures varied by type of speech turn (withdrawal ruptures, confrontation ruptures, and neutral content), we performed multivariate ANOVA (MANOVA) tests. In order to estimate the cutoffs, according to which the acoustic markers of the patient will differentiate a rupture from neural speech, we used a Receiver Operating Characteristic (ROC) Curve procedure (Youden, 1950). In cases where no cutoff exists in the literature, it is recommended that the Receiver Operating Characteristic (ROC) Curve procedure be used (Franco-Pereira, Nakas, & Pardo, 2020). The cutoffs were chosen by maximizing the Youden function, which is the difference between sensitivity rate (the probability of correctly classifying a rupture) and 1-specificity rate (the probability of incorrectly classifying a rupture) over all possible cutoff values (Youden, 1950).

Descriptive analysis was conducted to better understand and illustrate the association between ruptures and acoustic data. Descriptive analyses were conducted on the 16 sessions in this case study. The research team, which included three psychologists, watched the videos of all the patients' sessions, in order to segmentize and characterize the phases of therapy in which unique rupture patterns were evident. This was done while consulting with the patients' therapist. The treatment course was divided into three phases, each having a unique rupture dynamic. We then located and captured distinct

rupture episodes in each of the three therapy phases and integrated the acoustic results within their clinical context.

Results

Statistical analysis

We performed data screening and assumption testing. F0-span, shimmer, jitter, and pause proportion were normally distributed between the groups. However, articulation rate was not normally distributed but positively skewed, therefore we calculated a logarithmic transformation. The assumption of equality of covariance was not significant, matching the assumption of equal covariance matrices ($p > .001$). The assumption of homogeneity of variance for F0-span, shimmer, and jitter were not significant, indicating homogeneity of variance ($p > .05$). However, the articulation rate and pause proportion were significant, indicating that the assumption of homogeneity of variance was violated; therefore, we used and reported an unequal variance t-test (Welch's test).

We performed a MANOVA test to compare speech turn contents (confrontation ruptures, withdrawal ruptures, and neutral speech turns) for the five acoustic markers (F0 span, pause proportion, articulation rate, shimmer, and jitter). The overall multivariate effect of speech turn content was significant, Wilks' Lambda = .64, $F(10, 202) = 4.99$, $p < .0001$, $\eta^2 = .19$.

Four of the acoustic markers yielded a significant main effect for speech turn content: F0-span, pause proportion, articulation rate, and shimmer ($F(2, 105) = 5.01$, $p = .008$, partial $\eta^2 = .09$; Welch Statistic (2,55.26) = 28.13, $p < .0001$, partial $\eta^2 = .26$; Welch Statistic (2, 65.67) = 11.67, $p < .0001$, partial $\eta^2 = .08$; $F(2, 105) = 3.22$, $p = .04$, partial $\eta^2 = .06$, respectively), except for the jitter acoustic markers ($F(2, 105) = 1.15$, $p = .32$, partial $\eta^2 = .02$). To probe for the source of these effects, we conducted a *post hoc* Tukey's honestly significant difference (HSD) test.

Withdrawal ruptures

All four acoustic markers showed significant differences between the withdrawal ruptures and neutral speech turns in Tukey's HSD tests. Three acoustic markers (F0 span, pause proportion, and shimmer) were significantly higher for withdrawal ruptures than for neutral speech turns ($p = .01$, $p < .0001$, $p = .03$, respectively), and one (articulation rate) was significantly lower than neutral speech turns ($p = .01$) (Figure 1).

Confrontation ruptures

Two of the four acoustic markers showed significant differences between the confrontation ruptures and neutral speech turns in Tukey's HSD tests. Two acoustic markers (F0 span and pause proportion) were significantly higher for confrontation ruptures than for neutral speech turns ($p = .01$, $p = .002$, respectively). Two acoustic markers (articulation rate and shimmer) did not show a significant difference between the confrontation ruptures and neutral speech turns ($p = .16$, $p = .26$, respectively) (Figure 1).

To check the possible influence of time on the acoustic markers, we repeated the analysis with session (time) as a covariate in the multivariate analysis of covariance (MANCOVA), and received similar results regarding speech turn content. The main effect

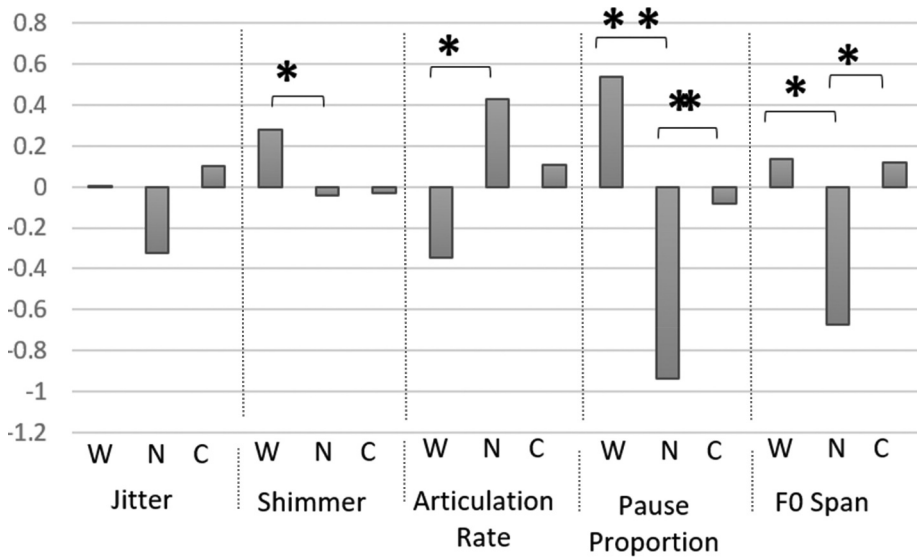


Figure 1. Differences between withdrawal ruptures (W), confrontation ruptures (C) and neutral speech turns (N) for all the acoustic markers. Note: W = Withdrawal ruptures; C = Confrontation ruptures; N = Neutral Speech; * $p < .05$, ** $p < .001$.

for speech turn content was significant, Wilks' Lambda = .64, $F(10, 200) = 4.96, p < .0001, \eta^2 = .19$, and the main effect for session was significant, Wilks' Lambda = .86, $F(5,100) = 3.17, p = .01, \eta^2 = .13$.

The results of the ROC procedure (Youden, 1950) indicated that the patient-specific cutoff values for each acoustic marker could significantly identify the ruptures (Table 1). In withdrawal ruptures, a chi-square test of independence suggests that speech turns with higher values are more likely to be identified as withdrawal ruptures, and less likely to be identified as neutral speech turns. These differences are significant concerning the F0-span ($X = 8.94, p < 0.05$), pause proportions ($X = 33.7, p < 0.01$), and shimmer ($X = 13.06, P < 0.01$). Regarding the articulation rate, the same pattern was found, meaning that speech turns with lower articulation rate are more likely to be identified as withdrawal ruptures than neutral speech turns, however this was not significant ($X = 9.3, p = .33$) (Table 2). In confrontation ruptures, a chi-square test of independence suggests that speech turns with higher values are more likely to be identified as confrontation ruptures, and less likely to be identified as neutral speech turns. These differences are significant

Table 1. Optimal Youden Index point: The cutoffs of acoustic markers for detecting confrontation and withdrawal ruptures by ROC procedures.

Rupture Type	Acoustic marker	1-specificity	Sensitivity	cutoff
Conformation ruptures	F0-span (Z)	0	0.38	0.72
	Pause (Z)	0.12	0.62	-0.05
Withdrawal ruptures	F0-span	0.06	0.51	0.47
	Pause proportion	0.24	0.97	-0.72
	Shimmer	0.06	0.59	0.006
	Articulation rate*	0.95	1	-1.16

* The articulation rate was multiplied by -1 to fit the direction of the other markers.

Table 2. Percentages within acoustic markers between the withdrawal ruptures and neutral speech (above and below cutoff).

	Acoustic Marker	Withdrawals Ruptures	Natural Speech
Above Cutoff	F0-span	94.7%	5.3%
	Pause Proportion	90.2%	9.8%
	Shimmer	95.7%	4.3%
	Articulation Rate*	67.9%	32.1%
Below Cutoff	F0-span	55.6%	44.49%
	Pause Proportion	7.1%	92.9%
	Shimmer	50%	50%
	Articulation Rate*	100%	0%

* The articulation rate was multiplied by -1 to fit the direction of the other markers.

Table 3. Percentages within acoustic markers between the confrontation ruptures and neutral speech (above and below cutoff).

	Acoustic Marker	Confrontation Ruptures	Natural Speech
Above Cutoff	F0-span	100%	0%
	Pause Proportion	94.3%	5.7%
Below Cutoff	F0-span	66.7%	33.3%
	Pause Proportion	59.5	40.5%

concerning the F0-span ($X = 9.16$, $p < 0.05$) and pause proportions ($X = 12.09$, $p < 0.01$) (Table 3).

Descriptive-analysis – case illustration

Presenting problems and patient description

The patient, Dan (pseudonym; all patient and therapist information was disguised to protect confidentiality), was in his early thirties, married and worked as an engineer. At the start of therapy, he presented with severe depression, anhedonia, sad affect, high self-criticism, and low motivation. He reported a tendency toward social isolation since childhood. The therapist, Ari (pseudonym), a clinical psychologist, was in his late forties.

Dan described that already as a child he felt different and odd, because of his tendency to daydream and his preference for solitary activities such as anime watching. He was raised by dedicated parents who, as he recalls, noticed from the beginning both his extraordinary cognitive abilities and his special emotional needs. They used to guide him on how to perform basic social skills. Throughout adolescence, he made deliberate efforts to mimic social skills, watching others interact and cognitively figuring out the principles at work. As a result, Dan succeeded to socialize with others, but the inner experience was one of faking for the outside, whereas inside he experienced himself as different and strange. During early adulthood, Dan continued to develop his professional skills. He successfully studied and established a career, met his future wife, and established a family. Although he succeeded in achieving these key milestones, he could not overcome his self-doubts, and consequently the depression followed.

Case formulation

Dan's difficulties can be understood to stem from a core conflict about his relationships that formed a maladaptive interpersonal pattern that alienated him from actualizing his genuine emotional needs, and consequently caused him to experience depression. The core conflict formulation was introduced in the fourth session by his therapist, Ari, who described Dan's wish to be loved, understood, and accepted for who he is. This wish, however, was in conflict with the way he felt that others reacted to it. He experienced others as rejecting, opposing, and disrespecting him. He also expressed his concern that others perceive him as full of flaws and as a "charity case." As a result, he withdrew from social contacts, felt depressed, disappointed, unloved, and ashamed of himself.

Course of treatment

Dan's treatment, whom we acoustically analyzed, demonstrates the importance of being able to detect ruptures. The therapy process is presented below in three phases, each having a unique rupture dynamic. Through the case study presentation, we tried to demonstrate the acoustic qualities of Dan's changing acoustic markers while the ruptures occurred.

First phase: "your lips move but i can't hear what you're saying."¹

At the beginning of therapy (sessions 2 and 4), Dan was emotionally withdrawn and verbally laconic. Although he described his history in detail and expressed his current distress, he did so in a matter-of-fact, detached, and aloof manner. His detached interpersonal attitude was also evident in the higher number of withdrawal than confrontation ruptures. Most of the withdrawal ruptures, however, went undetected, were not noticed by the therapist, and therefore remained unresolved. In particular, this first phase was characterized by many contents or affect split ruptures (Eubanks et al., 2015), with Dan often smiling and laughing in ways that were not compatible with the sad and painful events he talked about. His positive affect was misleading and was not recognized by the therapist as withdrawal ruptures, because it veiled the genuine painful emotions. However, it was apparent during the rupture, as measured later, that his voice and acoustic markers changed, sometimes with a hoarse and unsteady quality (high shimmer), other times with a slow speech production (decreased articulation rate) and wide pitch range (high F0 span). An example of such a rupture that went unnoticed by the therapist (and was captured later by the acoustic markers) occurred in Session 2. Dan spoke about a childhood memory concerning his father. While trying to figure out why Dan was so shy and reluctant, his father labeled him a "silent fish." Dan laughed and explained slowly (low articulation rate), and with a widely changing pitch (high F0 span), sounding as if he was half laughing and half crying, that his father was not aware that the problem was much worse: "It wasn't just fitting the fish syndrome (laughing). Actually, my father misdiagnosed me, and I have something much worse, some kind of brain damage." Dan was laughing loudly, and the therapist, who experienced discomfort and distraction, joined in the laughter. The unnoticed rupture dynamics jeopardized the alliance, and as later understood, Dan had experienced Ari as disrespecting and not caring enough, which further undermined the alliance. The impaired alliance dynamics triggered additional ruptures, and a vicious circle established itself. The patient continued to feel misunderstood and started to close up.

The dynamic of shutting down communication with the therapist was evident at Session 4. In reaction to an exploratory question: “How do you understand the sadness you feel?” Dan reacted with a withdrawal rupture; after a long silence he said slowly as trying to stress his words and with a trembling voice quality (high simmer): “Not a clue, what can one say about it?” He added nothing and looked down at the floor, avoiding eye contact. The therapists’ efforts to encourage exploration were not successful, and long silences were apparent, mostly coded as minimal response ruptures (Eubanks et al., 2015).

Ari consulted his supervisor in a video-supported supervision. As they were watching the session recording, they were able to retrospectively identify the withdrawal ruptures that Ari failed to detect originally. Ari realized that Dan’s enactment of laughing unconsciously pulled him into the maladaptive relational pattern of denying Dan’s genuine wish to be accepted and be loved. It was now clear to Ari that identifying and negotiating the withdrawal ruptures was a crucial process that could strengthen the alliance and help Dan make progress; otherwise, the treatment could further deteriorate.

Second phase: “I hear you’re feeling down, well, I can ease your pain.”²

Following the recommendations of Ari’s supervisor to attend to the withdrawal ruptures, a change occurred. Ari was now sensitive to the withdrawal cues and tried to attend to the ruptures directly by verbalizing what was happening between them. Following these changes, Dan started to gain insight into his maladaptive interpersonal pattern, as the following exchange demonstrates.

Dan: (Speaking slowly with several pauses) I felt really bad this week. I failed to meet the deadline for finishing the project and got an email reprimand about it. I’m a broken machine, that’s me (laughing loudly). [withdrawal rupture of content or affect split, self-criticism, and hopelessness].

Ari: (Not laughing and pausing for about half a minute) You know Dan, you’re telling me that you feel broken, while laughing about it. I can feel that some part of you is laughing and another inner part doesn’t want me to laugh about it. Let’s figure it out together?

Dan: You’re making too much of it. I’m just laughing, you know (gently smiling followed, by a long silence) [withdrawal rupture of content or affect split and minimal response].

Ari: Dan, I want to share with you that I actually felt sad when you laughed, and thought that you don’t deserve to be called broken at all.

Dan: O.K., so what do I deserve to be called?

Ari: I would guess that your wish is to be called the opposite. That people would treat you as a respected and beloved person, no?

Dan: (Laughing) Yeah, I can relate to that.

Ari: (Laughing too) With this kind of laugh I can join you now.

This clinical exchange illustrates that detecting the withdrawal ruptures was crucial for strengthening the alliance, opening an opportunity to negotiate Dan’s underlying

emotional needs, and for gaining insight into his reluctant stance. These changes lead to a corrective experience with Ari. Dan now felt progressively that Ari respected and cared for him.

Third phase: “shout, shout, let it all out.”

3

In the third phase, a change in the communication pattern became apparent. Dan was now able to directly communicate his needs in a confrontational manner. The confrontation ruptures were accompanied by vocal and prosody changes of wide-ranging F0 (sounds vital and assertive) and with long pause proportions, that were later measured. The following exchange illustrates the first time in therapy that Dan expressed directly what was bothering him about the study requirements. At Session 12, Dan expressed his concern about being recorded as part of the study requirements, by saying angrily (with a wide range of pitch moving rapidly from high to low pitch): “I don’t know what the viewers will think of me, they’ll judge me! It makes me angry that I can’t talk freely about all my issues.” Dan’s voice and speech, as later was assessed, contributed to the vital assertiveness of communication intention. These confrontation ruptures were coded as complaints or concerns about the parameters of therapy (Eubanks et al., 2015), and their resolution was therapeutic because it helped Dan gain insight into his wish, to be accepted.

This change in Dan’s ability to directly and angrily express his emotional needs was evident also at session 16, the final session of therapy. Dan explained that he was satisfied with feeling better, but added in a hostile tone with several pauses between words: “I noticed that my wife and I still have difficulties in communicating freely (pause). I feel that therapy didn’t change it much. It’s true that I feel better, but you couldn’t help me with my marital issues.” Regarding the acoustic profile the pauses that Dan inserted within his talking, contributed to the subjective impression of carefully selecting his words and thereby stressing them (“I felt ... pause ... that therapy ... pause ... didn’t change it much”). This acoustic change supported his mental intention of asserting himself. This was coded as complaints or concerns about progress in treatment and complaints or concerns about the therapist (Eubanks et al., 2015). Ari validated Dan’s experience, saying that he completely agreed that the therapy helped him feel better, and was sorry that he was not able to assist with the marital problems. Ari added: “You know, Dan, it’s very important to know about your doubts and dissatisfaction as well as the things you appreciate in therapy. It’s meaningful that you can express to me what bothers you. I know that at the start of therapy this was something that was hard for you to do.” These exchanges demonstrate the progress Dan made in his ability to directly express his confrontational stance, as the opening words of Tears for Fears reflect, Dan could now “shout and let it all out.”

Outcome and prognosis

Dan’s depressed mood improved over the course of therapy, as indicated by his experience in therapy and by the formal clinical interview (pretreatment scores of HRSD = 29 and a score of HRSD = 8 at session 16). His interpersonal relations underwent a thorough change because of the therapeutic focus on his core conflict and on rupture resolutions

efforts. As a result, Dan started to express his needs in a confrontational manner, which resulted in a growing ability to express his needs.

Although conceptually confrontational ruptures can be considered to reflect the same non-adaptive patterns of failing to assert one's emotional needs in a direct manner, as is the case with withdrawal ruptures, in the context of the treatment course narrative, they symbolize a meaningful change. The confrontational exchanges described above expressed Dan's growing ability to express his worries and needs in a direct manner, rather than concealing them under the regressed passive-aggressive communication pattern of withdrawing (the pretreatment maladaptive pattern). Later, in the follow-up session, Ari noticed that Dan developed a more sublimated way of communicating his wishes.

Discussion

Ruptures in the alliance have a potential to either cause therapy to deteriorate, at times leading to its premature termination, or to enhance it, leading to its success. Detecting the occurrence of ruptures is a critical phase in resolving them (Safran & Muran, 2000). Confrontation ruptures are easier to detect because they are characterized by overt expression of anger and dissatisfaction (Eubanks et al., 2015). By contrast, withdrawal ruptures can go unnoticed by therapists (Eubanks et al., 2018b). The present case-study was the first to explore whether acoustic data, obtained from a clinical setting of a particular patient (rather than actors or laboratory simulations of therapy) can be suggested as markers of ruptures in the alliance in a single case study.

The results suggest that the withdrawal ruptures can be detected based on acoustic markers in our specific case, and that this is an important first step towards understanding an important clinical process. Consistent with our hypothesis, withdrawal ruptures were characterized by greater pause proportion and lower articulation rate than neutral speech. This is consistent with previous findings showing the association between high rates of pausing and poorer alliance (Daniel, Folke, Lunn, Gondan, & Poulsen, 2018), and showing that the obstructive type of silence (Levitt, 2001) reflects the patient's disengagement from emotions or the therapy process.

Slow articulation rate has been shown to reflect hesitations (Watanabe & Rose, 2012). It has also been suggested that marked irregularities of patients' speech tempo in psychotherapy may be associated with an inward processing state of exploring and contemplating (Rice & Wagstaff, 1967). Accordingly, it may be useful for clinicians to consider several options in regard to the meaning of withdrawal ruptures. Especially when the articulation rate decreases, it may be beneficial to reflect whether it represents disengagement and hesitation, which are conceptually associated with the original withdrawal meaning, or a contemplating stance, which is conceptually associated with processing efforts.

Contrary to our hypotheses and to previous literature, withdrawal ruptures were characterized by higher F0-span and higher shimmer. These inconsistencies may be explained by the fact that the higher values of the two acoustic markers reflect an underlying negative emotional state of anger or tension that are not directly expressed in withdrawal ruptures, but that can be identified by the acoustic data.

Confrontation ruptures are more easily identified in treatment by the therapist because of their overt nature, and can also be detected by acoustic markers. Consistent with our hypothesis, confrontation ruptures were characterized by higher F0-span in our specific case. This is in line with previous literature showing an association between F0-span and a challenging and confronting stance (Weiste & Peräkylä, 2014). Contrary to our hypothesis, confrontation ruptures were characterized by higher pause proportion than neutral ruptures in our case. Whereas confrontation ruptures are considered to represent the direct expression of dissatisfaction and other disagreements (Safran & Muran, 2006; Safran, Muran, Samstag, & Stevens, 2001), pauses can sometimes represent an avoidant stance (e.g., Brown, 2008), which may represent an indirect expression of the underlying emotions.

However, Levitt (2001) suggested that in-session pauses in psychotherapy represent heterogeneous phenomena (Levitt, 2001). We refer here to confrontational pauses as part of the patient's continuous speech flow, and not to pauses that constitute a long silent segment. Concerning our case study, the "confrontation-pausing" may fit the description of interactional pauses of Levitt's (2001) in which patients may feel negative reactions towards the therapist and yet hold themselves back, in order to safeguard the therapeutic alliance (Levitt, 2001). In our case, the patient's confrontation-pauses can represent this ambivalent conflictual dynamic of assertiveness versus pausing. The clinical implication of this finding and conceptualization is that the unique CCRT formulation and the underlying personality tendencies should be taken into account when trying to understand pauses and their association with a rupture type. Future studies should investigate this surprising finding of the association between pauses and confrontation ruptures.

The findings suggest that the patient is characterized with a specific acoustic marker signature of ruptures, that is unique for him, and with specific cutoffs values. However, there was an inconsistency between the MANOVA test and the Chi-square regarding the articulation rate in withdrawal ruptures which can be explained by the reduced power of the nonparametric procedures (Chi-square test) compared to the corresponding parametric procedure (MANOVA) (McHugh, 2013). Future studies can explore whether other patients' cutoff values show similarities or show patient specificity due to patient characteristics.

When integrating several sources of information in Dan's case, (descriptive-analysis, ruptures episodes, and acoustic analysis), the relationship between ruptures and the acoustic markers can be demonstrated. In the first phase of the treatment, Dan's withdrawal ruptures masked his genuine interpersonal wish to be loved and accepted, a wish he could not yet directly articulate due to his core conflict. Dan expected others to reject and disrespect him, and his self-response was one of avoidance and depression. However, the acoustic markers, as measured later, were identified in his speech when a withdrawal rupture occurred. Dan's slow speech and frequent pauses communicated his hesitancy and his avoidant manner. As such, the acoustic markers could be considered as a hint or nonverbal communication effort that revealed Dan's underlying distress related to the withdrawal ruptures. We suggest that the withdrawal ruptures, together with the corresponding acoustic markers, represent Dan's tendency to conceal his desire and, at the same time, represent his unconscious need to be heard.

The undetected withdrawal ruptures deteriorated the alliance and could have led the treatment to premature termination if the therapist had not started to identify and handle

them. The therapist, with the supervisors' guidance, could hear Dan's communication efforts expressed in the withdrawal ruptures. Within the last phase, Dan was able to move to a more assertive relational position and start expressing his needs in the confrontation ruptures by articulating his anger and dissatisfaction.

Regarding the confrontation ruptures, Dan's acoustic markers changed in this phase of "Shout, Shout, let it all out" (Stanley & Orzabal, 1985) and supported his communication efforts, conveying a message of assertiveness. The high rates of pauses seemed to support Dan's efforts to emphasize the spoken words, and, as previously suggested, could safeguard the alliance (Levitt, 2001) while challenging the therapist. The wide F0-span which was expressed in a vital (Knowles & Little, 2016) and strong, assertive tone also supported Dan's communication efforts.

If replicated in a larger sample, the findings about the association between vocal acoustical signature and withdrawal ruptures can be beneficial for clinicians. In the case demonstration, the therapist, with the help of the supervisor, was able to detect the withdrawal rupture he initially missed. With this understanding, the therapist could notice and interpret the patient's underlying negative emotional tone (e.g., anger, tension) that was indirectly expressed in the withdrawal ruptures. In turn, the detection process enhanced the alliance and therapy in subsequent therapy sessions. Later in the therapy, the ruptures became more confrontational, which the therapist could more easily identify and negotiate. The meaning of these ruptures was the assertion of the patients' needs.

If replicated, the current findings can assist in implementing real-time feedback systems to identify withdrawal ruptures on the basis of acoustic data. Had the therapist in the above case study had real-time feedback to assist him in detecting the withdrawal rupture, and had he been aware of the negative emotional tone of the patient, he could have started resolving the withdrawal ruptures sooner, and advance the therapy more efficiently.

Novel developments in real-time computer-based feedback systems in psychotherapy have been shown to improve clinicians' efficacy (Imel, Caperton, Tanana, & Atkins, 2017). These technologies can help clinicians adapt the treatment to the patients' needs, consistent with the personalized treatment framework (Imel et al., 2017). Future studies will have to determine the threshold level for signaling to the therapist the possible occurrence of a rupture without disrupting the natural flow of the session (e.g., defining the signaling threshold for changes in pause length).

Based on findings of the current and previous studies, about the natural ability of human beings to perceive and process the emotional information that the prosody conveys, and to make valid judgments about it, we propose training clinicians to use their human ear, without computerized acoustic analysis, to improve their ability to detect ruptures.

At the first stage of the training, clinicians would listen to audio-only recordings of acoustic changes characteristic of ruptures and would be trained to explore the possible clinical meaning by answering four questions: (a) What were the acoustic changes that occurred (e.g., slower articulation rate)? (b) What was the clinical context in which they happened (e.g., the therapist was late arriving to the session)? (c) Does the acoustic change reflect a rupture (e.g., a long pause signals frustration and anger)? and (d) Is it clinically reasonable to initiate a rupture resolution process? At the second stage of intervention, clinicians would be trained in ways to initiate a therapeutic dialog about the acoustic changes by raising an exploratory question about the perceived changes and

offering to discuss their meaning. For example, in response to accelerated speech rate, the therapist may note “I can hear that your voice might tell us that perhaps something has happened here, you are talking much faster now. Can I ask what you feel right now?”

When interpreting the present findings, it is important to take into account the limitations of the study. An important limitation of the present study is the exploratory nature of the case study, which restricts the generalizability of the results beyond the individual patient and his unique characteristics. Different patients, with different characteristics, may have led to a different outcome in the acoustic data. Therefore, the current findings can serve to raise hypotheses that can be confirmed in future studies. Another limitation of this study is the choice of acoustic markers that were selected. Future studies should explore whether additional markers yield different results. In addition, the descriptive analysis of the patient’s sessions was chosen in order to examine and illustrate the association between ruptures and acoustic markers. Future studies can use a more systematic approach to examine the sessions’ rupture dynamics, such as in task analysis (Greenberg, 1984; 2007), to examine significant change processes and key moments in psychotherapy, combining qualitative and quantitative methods.

The present case-study demonstrates the potential of acoustic data to serve as markers of rupture in the alliance, especially as markers of withdrawal ruptures. The study sheds light on the involvement of underlying covert negative emotions in withdrawal ruptures that acoustic analysis can capture. If replicated, the findings can assist clinicians to better detect ruptures and to efficiently resolve them.

Notes

1. Gilmore, D. & Waters, R. (1979). Comfortably Numb. *The Wall. Pink Floyd. EMI Records.*
2. Gilmore, D., & Waters, R. (1979). Comfortably numb. *The Wall. Pink Floyd. EMI Records.*
3. Stanley & Orzabal (1985). Shout, *Songs from the Big Chair. Tears for Fears, Sony/ATV Music Publishing LLC, BMG Rights Management.*

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Notes on contributors

Tohar Dolev-Amit is a Doctoral Candidate on a president’s scholarship in the University of Haifa, Israel, and a researcher and lab manager in Dr. Sigal Zilcha-Mano’s lab. Her research focuses on processes of therapeutic change, and more specifically on the effect of the patient’s interpersonal style on the alliance, ruptures, and resolutions, and outcome of treatment.

Aviv Nof is a licensed clinical psychologist and a Ph.D. candidate in the University of Haifa, (at the psychotherapy lab of Dr. Sigal Zilcha-Mano). His research focuses on acoustic markers and the

therapeutic alliance. He is the founder and manager of Nof center for integrative psychotherapy in Israel. He integrates in his practice Supportive-Expressive short-term therapy, CBT, biofeedback and psychodynamic therapy.

Amal Asaad is a B.A psychology student at the University of Haifa. She is a research assistant at the psychotherapy lab of Dr. Sigal Zilcha-Mano, and she investigates the association between acoustic markers and ruptures in the alliances.

Amit Tchizick is a B.A student in Psychology and in the Honors Program in the University of Haifa, Israel. He is a research assistant at the psychotherapy lab of Dr. Sigal Zilcha-Mano investigating the effects of ruptures and resolutions during treatment on outcome. He works as a rehabilitative social guide in "Kivunim" association that strives to integrate people with high-functioning autism into the community.

Sigal Zilcha-Mano is an Associate Professor of Clinical Psychology and heads the Psychotherapy Research Lab in the Department of Psychology, University of Haifa. She is Associate Editor of the *Journal of Counseling Psychology*, and on the editorial board of *Journal of Consulting and Clinical Psychology*, *Journal of Clinical Psychology*, *Psychotherapy*, and *Psychotherapy Research*. She is a licensed clinical psychologist. Dr. Zilcha-Mano is the recipient of several career awards, including the International Society for Psychotherapy Research Outstanding Early Career Achievement Award, the American Psychological Foundation 2019 Division 29 Early Career Award, the International Society for the Exploration of Psychotherapy Integration New Researcher Award, and the Dusty and Ettie Miller Fellowship for Outstanding Young Scholars. She has received many research grants to support her work, including three research and equipment grants from the Israel Science Foundation, the U.S.-Israel Binational Science Foundation Grant (BSF), the JOY Ventures: Innovative Nero Wellness Grant, the MIT-Israel Zuckerman Award, the Society of Psychotherapy Research Grant, the Norine Johnson Psychotherapy Research Early Career Grant, Society for the Advancement of Psychotherapy, APA, and the Charles J. Gelso Grant, Society for the Advancement of Psychotherapy, APA. Dr. Zilcha-Mano has published over 85 peer reviewed papers in the past 6 years focusing on psychotherapy research and precision medicine in leading journals in these fields

ORCID

Aviv Nof  <http://orcid.org/0000-0003-1410-5586>

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