Fighting AN

A non-linear case-exploration of a
client-therapist text message interaction.

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Abstract

A non-linear dynamic systems (NDS) perspective was adopted for the longitudinal, explorative and non-linear analysis of a text-message conversation between a female with severe restricting type anorexia nervosa and her therapist. A priori, we argued that a rigid maintenance of recurrent behavioural structures could be indicative for a system's pathology (Miller, 1978). Hence, the text messages were analysed for the presence of recurrent structures by means of recurrence quantification analysis. Next, the interactional dominance of client and therapist was coded with the initiative-response coding system (Linell, Gustavsson, & Juvonen, 1988). The results yielded that the client showed higher levels of recurrent behaviour than the therapist. Moreover, higher levels of recurrent behaviour were negatively associated with the client's weight.

"Wanderer the road is your footsteps, nothing else; you lay down a path in walking"
Antonio Machado, 1930
(translated by Varela, 1987, p. 63)

Viewing humans as open complex systems implies a challenging duty for researchers in social science to attune their scientific enterprises in such way that they do justice to the implications that go along with such a viewpoint. In the current paper we therefore adopted a nonlinear dynamic systems perspective on the longitudinal exploration of a text message interaction between a client with severe restricted type anorexia nervosa and a therapist.

Nonlinear Dynamic Systems (NDS)

As the term indicates, a nonlinear dynamic systems (NDS) approach focuses on the behaviour of systems, broadly defined as a large set of interacting or interdependent components that form a unity (Bussolari & Goodell, 2009). The dynamical aspect of this framework expresses itself in the premise that, instead of *entities*, *processes* are the most fundamental ontological category (Rescher, 1996). Insofar as entities are given any ontological status, it is that of a relatively stable collection of processes during a specific time frame. Model wise, dynamic systems are mathematically described as a set of differential equations that reflect their states and trajectories in a (multi-) dimensional state space (Baranger, 2000). Importantly, the equations used to describe the trajectories of a *nonlinear* dynamic system in this space of alternatives include at least one variable that is raised to a power higher than one (Baranger, 2000). It is exactly this characteristic that makes an NDS approach particularly suitable for the study of biological systems.

Far from equilibrium

As early as in 1932, the physically open character of biological systems was already recognized by Bertalanffy, the founding father of general systems theory (Bertalanffy, 1950).Whereas closed systems conserve their energy, open systems exhibit a continuous exchange of matter and energy with the extra-systemic environment. This notion of openness was extended by Nobel laureate Prigogine, who theorized that an open system tends towards a self-sustaining state far from thermodynamic equilibrium as an effect of the nonlinear and recurrent interactions between its components (Prigogine & Stengers, 1984). These feedback mechanisms, out of which structure emerges are often termed self-organisation: the local-to-global emergence of structure as a result of recurrent feedback dynamics.

In the case of humans, such structure can be seen as a pattern of behaviour or cognition that is more likely to occur than other patterns (Thompson, 2007). In more general terms, structure refers to the constraints in phase space as a consequence of which trajectories have a relatively greater likelihood to occur in one region rather than in another. With respect to these so-called attractors in phase space, it is important to note that they are "structured structuring structures" (Dyke, 1988, p. 211), that is, they are structuring the

underlying dynamics while, at the very same time they are structured by these dynamics. Fundamental to all these processes is the openness of the system.

All open systems, including biological and thus human systems, therefore imply interconnectedness with their environment (Bertalanffy, 1950). Hence, the ontogenesis of patterns of behaviour, be it psychopathological or not, is inherently relational. More radically one could even state that the duality between internal and external contexts is neither epistemic nor ontic, but merely an epiphenomenon of our research methodologies (Jordan, 2008; Streeck & Scott Jordan, 2009). This notion has been recognized by a number of researchers in the field of social science (refs), and has far-reaching implications for (i) the discernment of scientific areas of interest as well as (ii) our subsequent investigation of these areas. Both matters will be clarified below.

Ontogenesis of patterns

As self-organisation describes the ontogenesis of patterns, this notion is of the utmost importance for understanding pathology, and subsequently for understanding psychotherapy. After all, it is the ontogenesis of pathology that implies the ontogenesis of change and thus inspires the therapeutic approach.

The notion that self-organisation at the intra-individual level cannot be described in isolation, has been very clearly instantiated by Patterson and colleagues (Patterson, 1982; Patterson, Reid, & Dishion, 1992) with their depiction of the coercive cycle in family system interactions. Following this description, parents and children co-create a pattern of interaction by reciprocally influencing each other in a negative way. More concretely, out of the parent's demands for compliant behaviour and the children's (escalating) oppositional behaviour, a state of (mutual) aggression arises, followed by a state in which the parents capitulate. It was found that such processes could eventually progress towards the child showing conduct problems in other situations as well. In later work (Granic, O'Hara, Pepler, & Lewis, 2007; Granic & Patterson, 2006), these states have been termed as emergent, which implies that they cannot be reduced to the components out which they arose. This irreducibleness makes it plainly visible that a dualism between sender-receiver or more broadly, between internal and external is untenable, in the psychological realm at least.

Recently, Jordan and colleagues (Jordan, 2008; Jordan & Ghin, 2006; Streeck & Scott Jordan, 2009) have added to this line of reasoning with their view on embodied meaning. In accordance with the enactive approach (Thompson, 2007), Jordan and co-workers theorize that because open systems are self-sustaining in an environment full of constraints, these systems are embodiments *of* these constraints, and therefore inherently meaningful. In other words, self-sustaining systems are "naturally and necessarily *about*" the context in which they live (Jordan, 2008, p. 1986; emphasis added). Over time, the system has embodied its past and thereby its adaptability to its ever-changing future. It is the level of this adaptability that is seen as indicative for psychopathology (Marks-Tarlow, 1999).

Over-determination

Also, from an NDS perspective, adaptability plays an important role in defining pathology. To that respect the following definition by Miller may be helpful:

> "Any state of a system is pathological in which one or more variables remain for a significant period beyond their ranges of stability, or in which the costs of adjustment processes required to keep them within their ranges of stability are significantly increased" (Miller, 1978, p. 81).

As being too flexible and being too stable are both indications of pathology, it can be derived that healthy behaviour arises out of an optimal trade-off between stability and flexibility (Swanson, 2005). Interestingly, this balance closely resembles the metaphorical interpretation of concepts like the "edge of chaos" (Kauffman, 1995) and "self-organized criticality" (Bak, 1996) with regards to psychopathology (Marks-Tarlow, 1999). In this respect, the notion of recurrence is of importance. Recurrence is considered a fundamental aspect of dynamical systems (Lewis & Douglas, 1998) and has also been given a place in the understanding of resilient psychological patterns (Lewis & Douglas, 1998). Hence, in terms of the above-mentioned definition of pathology by Miller, one could say that recurrent behaviour, though necessary for stability, could also indicate resilience to variability. If then, resilience costs a lot of energy, the system is called pathological.

It should be noted though that defining pathology as a deviation from the optimal trade-off between flexibility and stability is, in our view, merely a necessary condition for categorizing behaviour as psychopathological, and not a sufficient one. As with all definitions of psychopathology, context- and scale-dependency is fundamental. We think that we speak for the majority of people when we state that we would like our brain surgeon to have an extremely stable hand, and despite energy costs on behalf of the surgeon, we would not even contemplate to categorizing such behaviour as psychopathological.

The current study

In the current study we have attempted to approach a client-therapist interaction from an NDS perspective. The interaction at hand was between a therapist and L.M., a 25-year old woman suffering from severe restricting type anorexia nervosa (AN). Besides therapeutic meetings two times a week, almost daily telephone calls with the client and weekly parental support conversations, the therapist was also reachable by cell-phone via text messaging. The present exploratory investigation revolved around these text messages, sent during the period of one year.

As an NDS approach gives us the tools to quantify structures in the behaviour of an NDS, we questioned whether such an approach would provide us insight into (i) the structure of client-therapist interaction over time and, (ii) its relation with weight. Given the above-mentioned definition of pathology, we were particularly interested in possible recurrent structures in the text message conversation. Hence, we used recurrence quantification analysis (RQA) to quantify such structures.

Method

Participant

The current case study revolved around L.M., a woman aged 25 at the time of data collection, who has suffered from severe restricting type anorexia nervosa (AN) since 1998. The anorectic behaviour of L.M. expresses itself in very low food intake and excessive physical exercise (up to 15 hours a day). During this 12-year period of illness, L.M. has been hospitalized at least seven times for treatment of life-threatening underweight. The hospitalizations have not had the desired effect, and after her admission in June 2010, the treating physician prognosed L.M.'s demise in august 2010. Yet, this prediction proved to be wrong, whereas up until now (end of March 2012), L.M. is still alive and has not been hospitalized any more since her last admission in June 2010.

Starting with one therapeutic meeting a week, a new therapy commenced in June 2010 and extended to twice a week in October 2010. Besides these therapeutic meetings, almost daily telephone calls with the client and weekly parental support conversations, the therapist was also reachable by cell-phone via text messaging. L.M. gave her consent with regard to the use of those text messages and weight data for the use of the present study.

Data collection and preparation

Text messages

All text messages were inspected for transference errors. The errors manifested themselves in a mix up of sentences between texts, and odd displays of special characters. The transference errors were corrected before further data preparation. Originally, the data set used in this study consisted of 4037 text messages, containing 430,214 characters. These text messages were exchanged over a time period starting on June 7, 2010 and ending on July 2, 2011. All text messages were initially saved on the therapist's mobile device, before they were transferred onto a personal computer, in the form of an excel-file.

The texts sent by the client in the first half of November 2010, were lost due to device malfunctioning. Hence we also excluded the text messages sent by the therapist accordingly. Furthermore, the dataset contained days on which only *one* of the parties had sent text message(s). The messages from these days were excluded from the analysis, as the conversation *between* parties was the subject of interest. Next, the remaining text messages were arranged in so-called turns, that is, all consecutive text messages sent by one party *on a single day* (i.e. without an intervening message by the other party), were merged into one turn. These data preparations yielded a dataset we called the *single-day mergence*, which contained 1644 turns for the client, and 1756 turns on behalf of the therapist. For the analysis of patterns of interactional leading and following, this merging was extended, that is, also consecutive text messages sent by one party *on two consecutive days* were merged into one turn. This approach yielded 1637 turns for the client and 1653 turns

for the therapist, and was called the *double-day mergence* (DDM). Note that the number of turns for therapist and client in the DDM dataset is not equal, as the therapist initiated or concluding the conversations more often than the client did.

The data were explored at three levels: *characters, unaltered words* and *altered words*. For each level of analysis a different time series was used, based on an adapted version of the original data. The adaptations that were made for each of these levels can be found in table 1 and are briefly discussed below.

Characters. As the text input software of the mobile devices of the client and therapist automatically capitalized the first letter after a period, these capitals were changed into lower case characters. The rest of the data at this level remained unaltered and served as the input for data alteration at the level of *unaltered words.* For the construction of the time series, all characters were recoded into a number, so that each character was denoted by the same numerical code each time it occurred. The resulting time series were 275,861 and 239,404 data points long for the client and the therapist respectively.

Non-altered words. For the analysis on this level, all non-alphanumeric characters were removed. Furthermore, all remaining upper-case characters were transformed into lower-case characters. The resulting text messages served as input for data preparation at the level of *altered words*. For the construction of the time series, all words separated by white space were recoded into numbers, in such a way that each word was denoted by the same numerical code every time it occurred. This yielded two time series of length 58,284 and 47,338 for respectively the client and the therapist.

Altered words. In table 1 the adjustments of the texts made at this level are shown. To highlight the semantics of the texts we made some alterations, yet tried to stay as close to the original text as possible. It should be noted that instances of some linguistic categories are more common in Germanic languages (like Dutch), compared to English. However, we gave an English example of each alteration in the table. For the construction of the time series, all words were again recoded into numbers (in the same fashion as at the level of the non-altered words, mentioned above). After preparation on this level, the time series for the client and the therapist were respectively 60,255 and 49,003 data points long

Weight

Data concerning the weight of the client was obtained by self-report. On her own initiative, the client kept a very regular account of her weight in kilogrammes, from July 2, 2010 until February 23, 2011. The client stopped with this registration, because her weight exceeded 34 kilogrammes, a circumstance that she experienced as unbearable. As a result, she stopped with these measurements. Therefore, the dataset only consisted of weight data spanning 97 daily measure points. To avoid being intrusive, we did not ask the client to resume her registration.

From this time series, solely 81 time points were used in the analysis, since only then both therapist and client exchanged text message(s) with each other. This mutual exchange was a prerequisite for the planned correlational analysis.

Table 1
Alterations to the original set of text messages.

Level	Original text	Modified text	English example
Characters	Upper-case characters after a period	Lower-case characters	A → a
Un-altered Words	Non-alphanumeric characters	Removed	‘:) → removed
	Remaining upper-case characters	Lower-case characters	A → a
Alter words	Spelling errors	Corrected or removed when it was not clear what was meant	
	Compound words	Separated into their constituting free morphemes	smalltalk → small talk sleepwalk → sleep walk
	Plural	Singular	bicycles → bicycle
	Conjugations	Infinitive	goes → go went → go
	Oblique, reflexive, and possessive personal pronouns	Nominative personal Pronouns	us → we her → she mine → I
	Diminutives	The noun without its diminutive suffix	duckling → duck
	Comparative and superlative form of adverbs and adjectives	Positive form of adverb or adjective	taller → tall better → good
	Numbers below ten	Numerals	7 → seven
	Numbers referring to time	Numerals	16.00 hours → four hours
	Abbreviations	Its unabbreviated original	dr → doctor
	English words	Dutch words	kids → kinderen
	Texting slang	Its non-texting original	x → kiss w8 → wait
	Interjections	Standardised	hahahahahha → haha wauw → wow

Analytic strategy

Recurrence Quantification Analysis

For the current data exploration we used recurrence quantification analysis (RQA). Central to RQA is a distance matrix, which is computed between the rows of an embedded matrix, obtained from a time series (Orsucci et al., 2006). This matrix is the result of a time-delay embedding, which creates surrogate dimensions for the reconstruction of a phase space. The graphical representation of the distance matrix is called a recurrence plot (RP): a matrix with dots indicating recurrences. Subsequent quantification of these recurrences is done by means of RQA. For a detailed methodological description we refer to (Norbert Marwan, Carmen Romano, Thiel, & Kurths, 2007; Norbert Marwan & Kurths, 2002; Zbilut, Giuliani, & Webber Jr, 1998). The data used in this study consists of time series of nominal behavioural events (i.e. letters and words), which has implications for the parameter setting of the RQA. Following the procedure proposed by (Orsucci, et al., 2006) and by (Dale, Warlaumont, & Richardson, 2011), the following parameters were used: an embedding dimension (m) of 1, a time delay (τ) of 1, and a radius (ε) of 0. The latter parameter setting is indicating that only exact matches of letters and words are seen as recurrences.

Originally, RQA was invented for the analysis of patterns within the response of a single system, referred to in the current paper by *auto*-RQA (ARQA). An extension to ARQA was created by (N Marwan, Thiel, & Nowaczyk, 2002), that provided the possibility of analysing the time series of two coupled systems, termed as *cross*-RQA (CRQA). We used both variants (ARQA, CRQA) in our study, thereby concentrating on three measures of importance, recurrence rate, conversational leading and following and determination.

Recurrence rate (RR). The RR refers to the number of recurrences (black dots) in an RP, as a ratio (in percentages) of the total number of elements in the RP. In the current study, RR indicates the rate of recurring characters or words, either *within* the client's or therapist's own response (ARQA), or *between* therapist and client (CRQA). The single-day mergence set was used as input for these analyses.

The *conversational leading and following* (CLF) behaviour was also assessed with CRQA. In other studies, this behaviour is investigated by looking at the diagonal (the line of temporal incidence) of an RP. Yet, in the present study, the time series were of different length, making the interpretation of the diagonal of an RP problematic. Hence, we adopted a different procedure, by which the double-day mergence set was analysed. First, each turn was time coded, representing the date and time on which its constituting text messages were sent or received. An example of the applied procedure is the following: say the client sent a text message, which was replied by the therapist. The obtained time series for these two text messages (or better: turns) were analysed by means of CRQA. The resulting RR then reflects the therapist *repeating* characters or words written firstly by the client. Hence, the RR reflects the magnitude to which the client leads the conversation until so far. If the client then replies the initial response of the therapist, the RR reflects the magnitude to which the therapist leads the conversation, then consisting of the latter two turns. This analytical procedure was followed for all pairs of turns, yielding an average RR for turns in which the client was leading and an average RR for turns in which the therapist leading. The difference between these two averages

represents the relative leading behaviour, in which a positive value indicates that the client leads the interaction, versus a negative value that represents leading behaviour on behalf of the therapist.

Determinism (DET). DET is the percentage of recurrent points making up a diagonal line in the RP. In our study, such diagonal lines refer to the recurrence of *sequences* of characters or words, again either *within* the client's or therapist's own response (ARQA), or *between* therapist and client (CRQA).

Shuffling

To obtain a means of assessing the deviation of the structure of analysed text messages from the structure of random sequences, the time series were shuffled and then compared to their original counterparts. This procedure applies only to DET, but not to RR, as with regard to latter, the total number of recurrent points is not affected by shuffling.

Bootstrapping

Bootstrapping is a nonparametric method for estimating confidence intervals around statistics of interest by means of resampling the data. For RQA-measures, Schinkel, Marwan, Dimigen, and Kurths (2009) have described the so-called structure preserving resampling procedure, which was followed in the current study for obtaining variance estimates of DET. The variance of RR was not estimated as Schinkel, et al. (2009) have argued that this approach is restricted to DET (and some other RQA-measures not used in this study). In our study, this procedure entailed a thousandfold *resampling with replacement* of the distribution of recurrent points, resulting in 1000 surrogate distributions of recurrent points. Each of these distributions served as input for the calculation of DET, which subsequently yields a bootstrapping distribution of 1000 surrogate DET measures. The range of the two-sided 95% confidence interval (CI) was then determined by calculating the percentiles corresponding to 2.5% and 97.5 %. Non-overlapping CIs indicate a significant difference between the measures.

Analysis of communicative dominance

Initiative-response analysis (IR) measures the communicative dominance in interacting dyads by means of classifying conversational turns into categories that reflect the amount of control exerted on the course of the conversation (Linell, et al., 1988). In that respect, each turn was coded in relation to its foregoing and subsequent turn, which resulted in an assessment of leading, following, initiating and ignoring behaviour during conversations. Each of the 18 mutually exclusive categories (see Linell, et al., 1988 for a detailed specification of all categories), used in IR, is rated, stretching from 1 (totally dependent and not proactive at all) to 6 (independent and strongly proactive). All scores were thereafter averaged per interlocutor, yielding the so-called IR index. The difference between these indices, the *IR difference score*, reflects the balance of dominance during a conversation and was the only IR-based measure that was used in the present study. A *positive* IR difference represents that the client was more dominant during a conversation, whereas a *negative* IR difference expresses more communicative dominance on behalf of the therapist.

For IR, the raw dataset was used. Yet, consecutive text messages were merged into one turn if, within a half hour period, only one interlocutor had sent text message. This mergence resulted in 1880 coded turns for the therapist and 1680 coded turns on behalf of the client. As the entire text message conversation spanned 296 days, the first text of a day was always coded as an initiative (either strong or weak) regarding a new and independent subject, unless it was unquestionable that the concerning text message was a reaction to or continuation of (an initiative in) a text message sent on the day before.

Explorative Strategy

Our exploration of the data consisted of analysing the data at different resolutions, that is, we varied the number of consecutive days that were considered to constitute a single time point. This resolution ranged from a single day up to a group of seven consecutive days. In case of RQA and IR, a greater resolution implied that the time series spanned multiple days. For weight, the average was taken when a time series covered multiple days. Note that creating a cluster of multiple days prerequisites complete weight data from each day present in that cluster.

Results

In the results below we first present the weight of the client during the first months of therapy. Next, we compared the CRQA and ARQA measures with their shuffled counterparts. Thirdly, we provide the comparison between the ARQA measures of the client versus those of the therapist. Subsequently we display the measures of communicative dominance and their mutual associations. Lastly, the correlations between all RQA and IR –measures with the weight of the client during the first months of therapy are presented.

As the patterns across the different datasets were very similar, only the results of the analyses of the altered words are presented.

Weight

Figure 1 below depicts the development of the client's weight in kilogrammes during the first months of therapy. It can be seen that, notwithstanding some fluctuations, weight increases over time. Each dot in the graph represents a measurement of weight (N = 97). On days without a dot, the client refrained from measuring her weight or from noting it down.

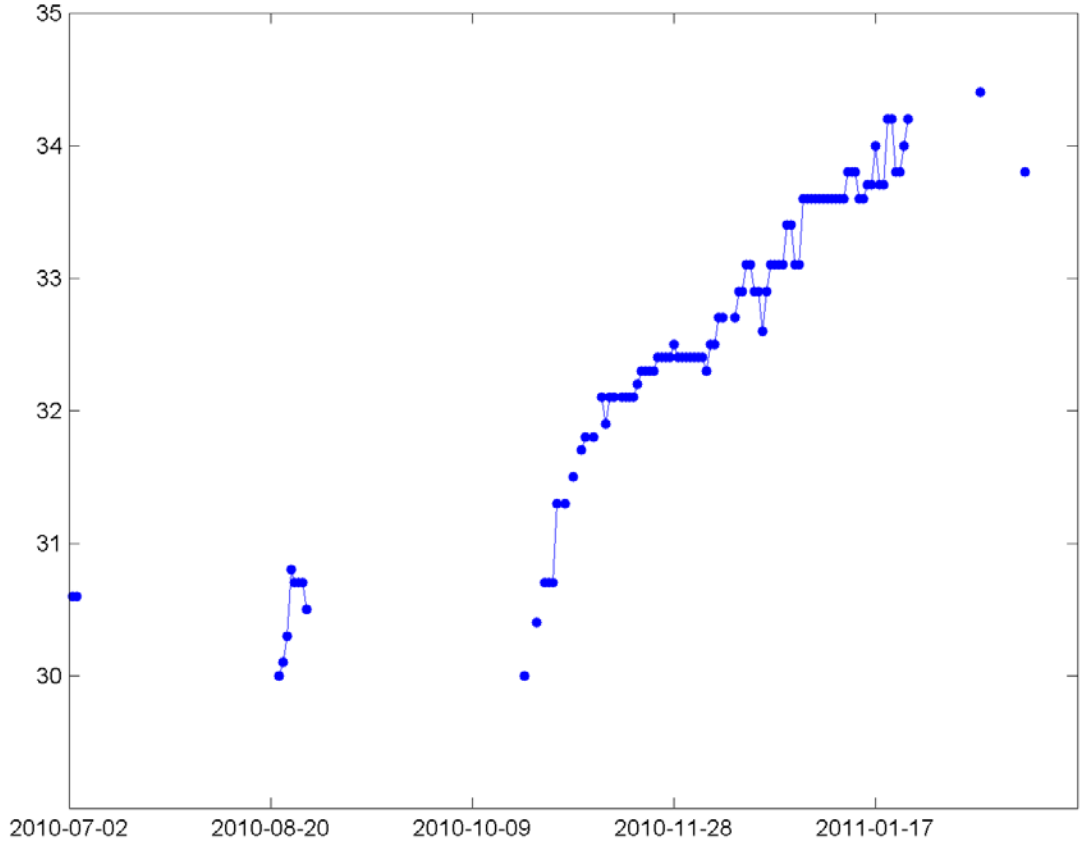

Figure 1. Weight measurements in kilogrammes of the client (*N* = 97)

CRQA and ARQA measures versus their shuffled counterparts

For both CRQA and ARQA, we first examined whether the measure of determinism (DET) was different from its shuffle-based counterpart (DET_s). For purposes of clarification, we plotted figure 2 as an example of a CRQA analysis. This graph shows the course of DET (blue) and DET_s (red) with their 95% confidence intervals over time. A resolution of two was used, which means that all measures were calculated *per two days*. The grey-shaded parts of the graph indicate that the two 95% confidence intervals did *not* overlap, in this case indicating that DET was significantly higher than from DET_s. For figure 2, this conclusion can be drawn for 89 of the 135 time points. Furthermore, on average DET was significantly higher than DET_s as tested with a paired samples *t*-test ($t(134) = 14.47$, $p < .001$).

The abovementioned procedure of analysis was followed for both CRQA and ARQA measures of determinism for all resolutions. The results of this procedure are displayed in table 2.

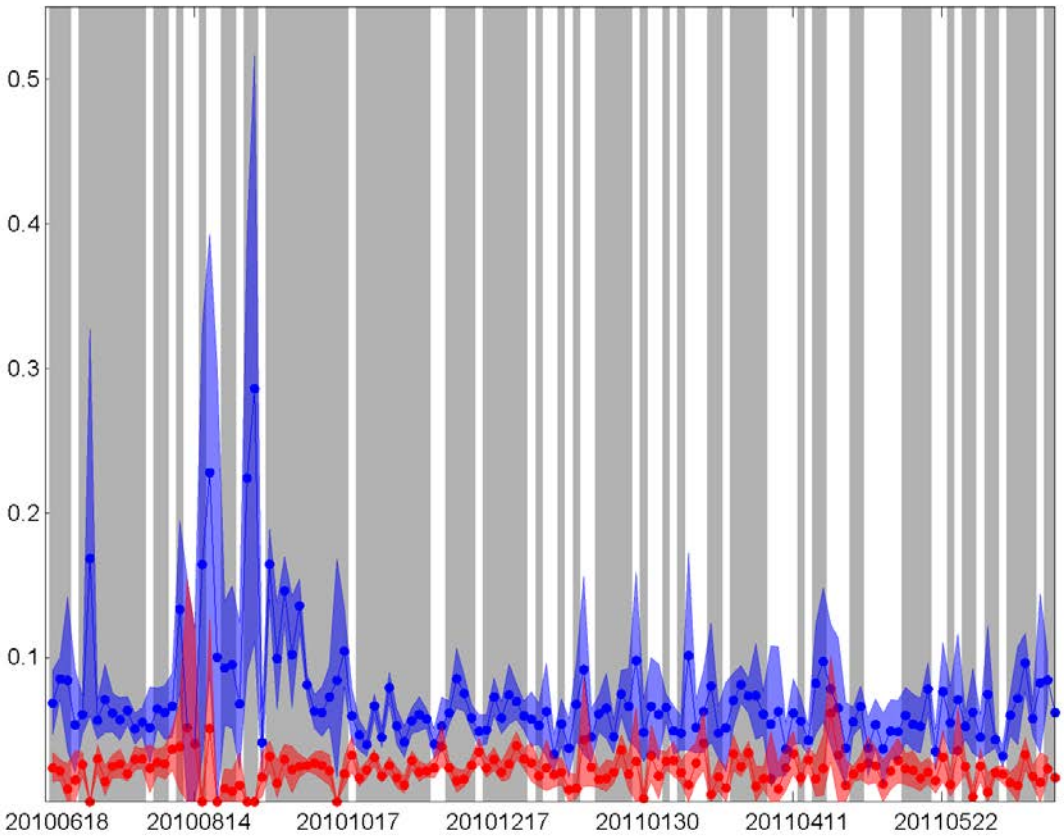

Figure 2. Course of DET (blue) and DET_s (red) with their 95% confidence intervals over time

Table 2

Comparison of RQA-Measures with Their Shuffled Counterparts

		Cross RQA				Auto RQA							
						Client				Therapist			
Res[1]	Total number of data-points	Mean Difference score DET-DET_s	Paired *t*-test	Effect size[2]	Number of data points on which DET > DET_s	Mean Difference score DET-DET_s	Paired *t*-test	Effect size[2]	Number of data points on which DET > DET_s	Mean Difference score DET-DET_s	Paired *t*-test	Effect size[2]	Number of data points on which DET > DET_s
	N	*M* (*SD*)	*t* (df)	*d*	n (%)	*M* (*SD*)	*t* (df)	*d*	n (%)	*M* (*SD*)	*t* (df)	*d*	n (%)
1	296	6.76 (8.57)	13.52 (295)***	0.79	118 (39.86)	6.13 (9.46)	9.27 (295)***	0.65	134 (45.27)	4.62 (8.13)	7.37 (295)***	0.57	93 (31.42)
2	135	4.88 (3.92)	14.47 (134)***	1.24	89 (65.93)	6.96 (6.62)	12.21 (134)***	1.05	107 (79.26)	5.26 (3.85)	15.88 (134)***	1.37	85 (62.96)
3	82	4.09 (2.50)	14.82 (81)***	1.64	69 (84.15)	6.43 (4.69)	12.40 (81)***	1.37	79 (96.34)	5.18 (3.41)	13.73 (81)***	1.52	70 (85.37)
4	58	3.87 (2.60)	11.35 (57)***	1.49	54 (93.10)	5.55 (2.54)	16.63 (57)***	2.19	55 (94.83)	4.90 (3.04)	12.26 (57)***	1.61	52 (89.66)
5	46	3.68 (2.45)	10.20 (45)***	1.50	46 (100.00)	5.46 (2.40)	15.44 (45)***	2.28	46 (100.00)	4.65 (3.18)	9.92 (45)***	1.46	44 (95.65)
6	35	3.33 (2.18)	9.03 (34)***	1.53	35 (100.00)	5.46 (2.72)	11.89 (34)***	2.01	35 (100.00)	4.87 (3.20)	8.98 (34)***	1.52	34 (97.14)
7	27	3.18 (1.81)	9.12 (26)***	1.76	27 (100.00)	5.35 (2.91)	9.56 (26)***	1.84	27 (100.00)	4.81 (3.74)	9.11 (26)***	1.29	27 (100.00)

Note: [1]Res = Resolution, the cluster of consecutive days.

[2] The effect size used was Cohen's *d*.

*$p < .05$, two-tailed. **$p < .01$, two-tailed. **$p < .001$, two-tailed.

Table 2 shows that, the lower the resolution, the larger the percentage of data points on which DET is significantly larger than on its shuffle-based counterpart (DET_s). This finding indicates that coarsening the resolution reduces the probability that such patterning occurs by chance. However, choosing a lower resolution goes at the cost of data points. That is, as we have data of only 296 days relative to a total of 391 days that make up the entire timespan of data collection, there are gaps between data points. This entails that, when using groups of seven consecutive days, one loses more data points than when using a resolution of only two days. As a result, for a resolution of seven days, only (27 × 7 =) 189 days with text messages are included in the analyses, versus (135 × 2 =) 270 days in the case of a resolution of 2. For our analytic approach we therefore decided that all results would be presented for all resolutions

Furthermore, it is important to acknowledge the effect of time series' length when comparing measures with their shuffle-based counterparts. That is, the longer the time-series, the less likely that a shuffled time series will yield the same results. Hence, the observation in table 2 that the client shows more often a difference between DET and DET_s than the therapist, is probably due to the fact that per single day, the client on average sent significantly longer text messages than the therapist, $M(SD)$ = 203.56 (153.25) and $M(SD)$ = 165.55 (119.53) respectively ($t(295) = 8.21$, $p < 0.001$).

ARQA

RR client and RR therapist

First, we compared the RR-measures that were the result of the two separate ARQA of the client's and therapist's text messages. The comparison yielded that, on average and across all correlations, the mean RR of the client was higher than that of the therapist as measured with a paired samples t-test (ps < .001, table 3). Next, the correlation between the RR of the client and that of the therapist was investigated, yielding a positive association between the two measures across all resolutions (ps < .001; see table 3 for the results).

DET client and DET therapist

We compared the DET resulting from the ARQA of the text messages of the client with the DET resulting from the ARQA of the text messages of the therapist, which involved a comparison of the 95 % confidence intervals (95% CI) for DET at each data point. Overlap between the CIs indicates a non-significant difference, whereas a significant difference is showed by *non*-overlapping CIs. This comparison gives us three possible solutions for each data point: (i) the 95% CI do not overlap while the client shows a *higher* DET than the therapist (client > therapist), (ii) the 95% CI do not overlap while the client showed a significantly *lower* DET than the therapist (client < therapist), and (iii) the 95% CI do overlap, indicating both therapist and client did not differ significantly with regard to DET (client = therapist). For all resolutions it was found that the largest portion of data points showed a *client = therapist* solution (ranging from 48.57 % to 77.02% across resolutions). This means that for most data points the DET of the client and the therapist did not differ

Table 3

Comparison and Associations of ARQA Measures Between Client and Therapist

		RR				DET			
Res[1]	Total number of data-points	Mean Difference score between RR_client and RR_ therapist	Paired *t*-test	Effect Size[2]	Correlation between RR_client and RR_therapist	Mean Difference score between DET-client and DET_therapist	Paired *t*-test	Effect Size[2]	Correlation between DET_client and DET_therapist
	N	*M* (*SD*)	*t* (*df*)	*d*	*r* (*df*)	*M* (*SD*)	*t* (*df*)	*d*	*r* (*df*)
1	296	0.20 (0.54)	6.18 (295)***	0.03	0.23 (294)***	2.00 (11.04)	3.12 (295)**	0.18	.13 (294)*
2	135	0.18 (0.39)	5.49 (134)***	0.03	0.30 (133)***	1.98 (7.44)	3.09 (134)**	0.27	.35 (133)***
3	82	0.16 (0.23)	6.00 (81)***	0.03	0.58 (80)***	1.56 (4.94)	2.85 (81)**	0.31	.54 (80)***
4	58	0.15 (0.18)	6.64 (57)***	0.02	0.66 (56)***	0.82 (2.99)	2.09 (57)*	0.27	.58 (56)***
5	46	0.16 (0.17)	6.33 (45)***	0.02	0.66 (44)***	1.14 (2.44)	3.18 (45)**	0.47	.69 (44)***
6	35	0.14 (0.14)	6.12 (34)***	0.02	0.75 (33)***	0.87 (1.85)	2.77 (34)**	0.47	.85 (33)***
7	27	0.16 (0.17)	7.09 (26)***	0.02	0.82 (25)***	0.78 (1.66)	2.45 (26)*	0.47	.86 (25)***

Note: [1]Res = Resolution, the cluster of consecutive days.

[2] The effect size used was Cohen's *d*.

*$p < .05$, two-tailed. **$p < .01$, two-tailed. **$p < .001$, two-tailed.

significantly. Yet, the second largest portion of data points showed a *client* > *therapist* solution (ranging from 19.59% to 42.86% across resolutions), reflecting a significant higher DET of the client relative to the therapist. The rest of the points indicated a *client* > *therapist* solution (ranging from 2.96% to 14.81% across resolutions). Moreover, on average, the DET of the client was significantly higher than that of the therapist as tested with a paired-samples t-test across all resolutions (*p*s < .05; see table 3 for the results).

Subsequently, the association between the DET measures of client and therapist was investigated (table 3). This yielded that across all correlations there was a positive correlation between DET of the therapist and the client (*p*s < .05). This indicates that, despite differences in ARQA DET, the two measures were related positively: a higher proportion of recurrent sequences of words of the client was associated with a higher proportion of recurrent sequences of words of the therapist.

Interactional Dominance

Across all resolutions, the mean RR of the CRQA after a client had sent a text message (client leading) was found to be significantly higher than the mean RR after the therapist had sent a text (therapist leading; *p*s < .001; see table 4 for the results). This indicates that, on average, the client lead the interaction. In figure 3 the course of the difference in leading behaviour over time is graphically displayed. It can be seen that most of the values are positive, indicating mostly leading behaviour of the client. Yet, over time, this positive difference does seem to decrease slightly.

Moreover, it appeared that the difference in dominance as measured by means of the IR analysis was positively correlated to the difference in leading and following for most resolutions (see table 4). This indicates a positive relationship between the difference in dominance and the difference in leading and following behaviour as calculated with the CRQA measures. The course of the difference in dominance over time can be seen in the figure 4. A positive value reflects a positive IR difference, which indicates that the client was more dominant. It can be seen that over time, this difference appears to decrease and even become more negative.

Tabel 4

Measures of Interactional Dominance

Res[1]	Mean difference in leading	Paired *t*-test	Effect Size[2]	Correlation with IR-diff
	M (*SD*)	*t* (*df*)	*d*	*r* (*df*)
1	.31 (.71)	7.33 (292)***	0.43	.12 (291)*
2	.28 (.41)	6.84 (133)***	0.68	.26 (132)**
3	.32 (.39)	7.30 (80)***	0.81	.37 (69)**
4	.28 (.24)	9.09 (56)***	1.18	.46 (48)***
5	.31 (.24)	8.71 (44)***	1.28	n.s.
6	.29 (.23)	7.40 (34)***	1.24	n.s.
7	.29 (.22)	6.80 (26)***	1.32	n.s.

Note: [1]Res = Resolution, the cluster of consecutive days.
[2] The effect size used was Cohen's *d*.
*$p < .05$, two-tailed. **$p < .01$, two-tailed. **$p < .001$, two-tailed.

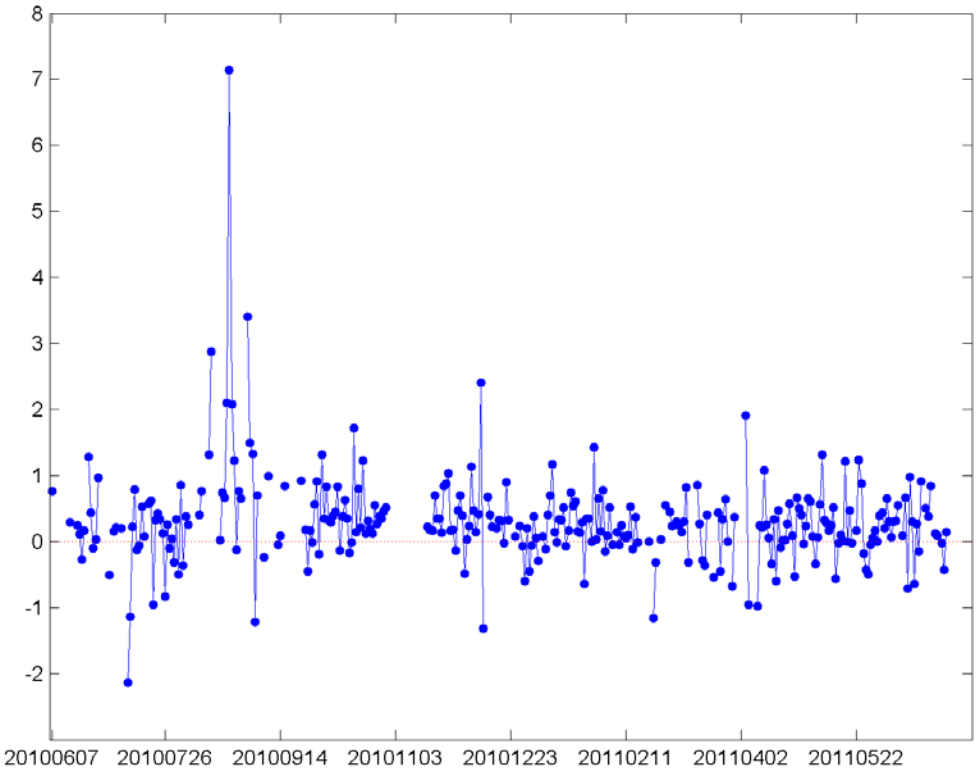

Figure 3. Difference in leading behaviour over time. Positive value indicate that the client leads on average

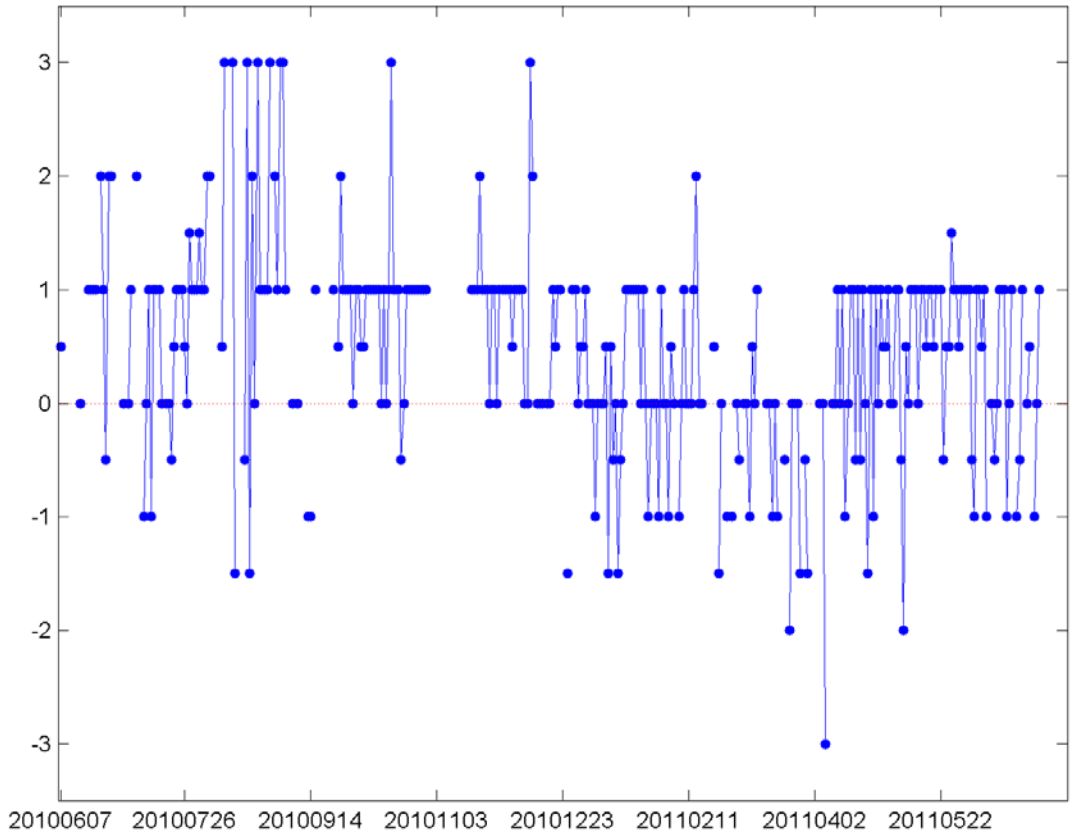

Figure 4. Difference in interactional dominance (IR-diff), positive values indicate that the client was on average more dominant

The association of RQA- and IR-measures with weight

All associations between the RQA- and IR-measures with weight are reported in table 5. For ARQA, the correlational analysis yielded that the recurrent behaviour (either RR or DET) of the client was negatively related to weight, indicating that the higher the level of recurrent behaviour, the lower weight. However, this was not the case for all resolutions. The recurrent behaviour of the therapist was only for one resolution significantly correlated to weight.

The measures from the CRQA yielded a more consistent pattern of associations with weight. All three measures (RR, DET and the difference in % leading) were negatively correlated with weight for most resolutions. This indicates that more recurrent behaviour between client and therapist was related to lower weight. Moreover, the magnitude of the difference with which the client lead the interaction was significantly correlated to weight, indicating that the more the client lead the interaction, the lower her weight was.

Also, the difference in dominance was negatively related to weight for resolutions 1 until 4, showing that the more dominance the client exhibited, the lower her weight was.

Table 5

	ARQA				CRQA			Linell
	Client		Therapist					
Res[1]	RR	DET	RR	DET	RR	DET	Difference in % leading	IR-diff
	r (*df*)	*r* (*df*)	*r* (*df*)	*r* (*df*)	*r* (*df*)	*r* (*df*)	*r* (*df*)	*r* (*df*)
1	n.s.	n.s.		n.s.	-.43 (79)***	n.s.	-.40 (77) ***	-.46 (79) ***
2	-.54 (34)***	n.s.	n.s.	n.s.	-.48 (34)**	-.49 (34)**	-.50 (32) **	-.51 (34) **
3	-.71 (21)***	-.55 (21)**	n.s.	n.s.	-.62 (21)**	-.63 (21)**	-.60 (21) **	-.62 (21) **
4	-.72 (15)**	-.64 (15)**	n.s.	n.s.	-.66 (58)***	-.66 (15)**	-.71 (13) **	-.49 (15) *
5	n.s.	n.s.	n.s.	-.70 (9)*	n.s.	-.72 (9)*	-.74 (8) *	n.s.
6	n.s.	n.s.	n.s.	n.s.	n.s.	-.82 (10)**	-.77 (8) **	n.s.
7	n.s.	-.82 (6)*	n.s.	n.s.	n.s.	-.83 (6)*	-.83 (5) *	n.s.

Note: [1]Res = Resolution, the cluster of consecutive days.

*$p < .05$, two-tailed. **$p < .01$, two-tailed. **$p < .001$, two-tailed.

Discussion

In this study we explored a text message conversation between a client (L.M.) with severe restricting type anorexia nervosa (AN) and her therapist. The conversation spanned more than a year and was analysed by means of recurrence quantification analysis (RQA) and initiative response (IR) analysis. The results can be summarized into four main points: (i) the analysis of the text messages reveals that the levels of structure present in these messages exceeds the levels of structure one would expect on the basis of chance; (ii) recurrence of single states (RR) or sequences of states (DET) seem to be relatively more present in the text messages sent by the client compared to those by the therapist; (iii) recurrent patterns in the text messages are related to the hallmark measure of the pathology under investigation (i.e. weight); (iv) the same goes for conversational dominance. We will start by discussing points ii until iv, before heading on to the discussion of point i, which is more methodological by nature.

Recurrent structures and pathology

Although the ARQAs yielded that the client exhibited higher recurrent conversational behaviour compared to the therapist, this does not necessarily imply pathology. Highly recurrent behaviour only becomes a problem when, freely interpreting Miller (1978), the maintenance of these recurrent patterns depletes the system of its resources. Yet, our data do seem to support this account of pathology with regard to recurrence in text messages. That is, the more often the client repeated herself during conversations with the therapist, the more prone she was to losing weight. Over time it furthermore appeared that, given the negative relation between weight and recurrent behaviour, the client repeated herself less as her weight increased. In terms of the structure of the client's text messages it thus seemed that her texts increased in complexity over time, reflected in more variability. From this, one could argue that the texting behaviour of the client of the present study reveal underlying system dynamics that are characterised by relative rigidity and that these dynamics are closely related to the anorectic behaviour.

The recurrent behaviour that was disclosed by the CRQA demands a different explanation. Firstly, measures of recurrence yielded by CRQA represent the level of *linguistic coupling* between client and therapist. Given the alterations we made to the text, such linguistic coupling is mostly the effect of talking about the same topic. Several empirical studies indicated that an interpersonal coupling is linked to feelings of connectedness (Lakin & Chartrand, 2003), mutual understanding (Shockley, Richardson, & Dale, 2009) and more cooperative abilities (Valdesolo, Ouyang, & DeSteno, 2010). Yet, we found that a higher coupling was related to *lower* weight. How do these two accounts converge? This is where the importance of the idiosyncrasy of psychological research comes into play. That is, the meaning of interpersonal coupling *against the background of L.M.'s behaviour* can be completely different compared to the nomothetic effect that such a coupling is supposed to have. Namely, accepting our finding that L.M.'s responses are indeed a reflection of a rather rigid system, the range of states in which a linguistic coupling can be attained is rather restricted too (i.e. mostly weight- and food-related). In other words, it seems plausible that showing interest in other topics

(including those introduced by the therapist) was momentarily not within the bounds of the client's behavioural possibilities. This implies that, when there is linguistic coupling, the topic of discussion is probably related to something that is within the range of the client's interest. Both the measures of interactional dominance (IR and CLF) and the recurrence measures yielded form CRQA (RR and DET) show that staying within the client's range of topics is indeed associated with lower weight.

Variability

To understand this, the notion of variability needs some further explanation. In the introduction, it was already argued that an overly flexible or overly rigid system could signal a system's pathology (Miller, 1978; Swanson, 2005). With regard to L.M., the latter structure seems to fit best, as the anamnesis indicated the twelve-year long resiliency of anorectic behaviour with regard to several environmental interventions. Hence, from a therapeutic perspective, one would arguably strive for more flexibility of the system's responses to external perturbations. In Miller's words: to increase the ranges of stability in such way that the costs of the adjustment processes to keep the system within this range could go down. This is in accordance with Fogel and Garvey (2007) who argued that, for behaviour to emerge beyond ingrained patterns, variability should be added.

The question then remains: variability added in what? Fogel and Garvey (2007) argue that variability is an intrinsic property of systems that are alive, which becomes visible when looking at so-called frames: "segments of co-action that have a coherent theme […] that take place within a particular location (in space or in time), and that involve particular forms of mutual co-orientation between participants." (Fogel & Garvey, 2007, p. 253). This appears to be closely related to the linguistic coupling described above. For a linguistic frame, the therapist can only add variability by discussing a topic that is outside the range of interest of the client. However, while adding variability, the therapist should at the very same time remain coupled enough to keep the client interested. In the current case it was the therapeutic challenge to balance between too little linguistic coupling, which may result in "losing" the patient, and too much linguistic overlap which may result in constant or even increasing rigidity in the client's system.

Limitations and prospectives

Our finding that the analysis of text messages revealed higher levels of structure than one would expect on the basis of chance has mostly methodological implications. That is, text messages do seem to lend themselves for nonlinear time series analysis, provided that they are of sufficient length. Obviously it is precisely this prerequisite that is incompatible with text messages, given that the standard length of one message is only 160 characters and it literally pays to be brief. As in the present paper, this issue could be tackled by looking across resolutions, thus investigating the structure of text messages at different levels of mergence.

In this study we have restricted ourselves to a descriptive approach resulting in correlational measures only. For the future, it would be interesting to look at nonlinear transitions and their relation to external measures of psychopathology as well.

Additionally, we believe that the notion of variability deserves more attention in the context of therapeutic interventions. Although currently we have only investigated this notion with regard to linguistic coupling, we by no means underestimate the importance of non-verbal communication in interaction and its potential for psychotherapy (Fogel & Garvey, 2007; Ramseyer & Tschacher, 2011)

Conclusion

Principally, our explorative analytical enterprise has strengthened our belief that, apart from its content, it is the *structure* of a system's response that gives meaningful information. It directs us towards adopting a perspective that grants such information a fundamental position, despite the resiliency of common perspectives that claim otherwise.

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