ELSEVIER

New Ideas in Psychology 26 (2008) 295–308

NEW IDEAS IN PSYCHOLOGY

www.elsevier.com/locate/newideapsych

Organization of the narrative components in autobiographical speech of anorexic adolescents: A statistical and non-linear dynamical analysis

Karyn Doba[a,b], Jean-Louis Nandrino[a,b,d,*], Annick Lesne[e], Christine Humez[f], Laurent Pezard[c,d,1]

[a] *URECA, Université Lille 3, Villeneuve d'Ascq, France*
[b] *Fondation Santé de Etudiants de France, Clinique Medico-Psychologique, Villeneuve d'Ascq, France*
[c] *Laboratoire de Neurosciences Cognitives and Imagerie Cérébrale (LENA-CNRS UPR 640), Paris, France*
[d] *Institut International Erasme, Université Lille 3, Villeneuve d'Ascq, France*
[e] *Laboratoire de Physique Théorique des Liquides (CNRS UMR 7600), Université Paris 6, Paris, France*
[f] *Départment de Psychologie, Université Charles de Gaulle Lille 3, Domaine du pont de bois, 59653 Villeneuve d'Ascq, France*

Available online 17 September 2007

Abstract

Family theories of anorexia nervosa point out that patients' autobiographic speech may reflect internalized family interactions. Our study characterizes the statistical distribution and temporal organization of the narrative components describing personal relationships in anorexic and control subjects. Semantic components related to personal interactions were encoded from life narratives of 14 adolescent girls with anorexia nervosa (restrictive type) and of 13 matched healthy adolescent girls. Speech analysis was performed using both statistical methods and non-linear time-series analysis. Static indices showed an over-representation of family relations and an under-representation of love relations in anorexic patients. Dynamical indices showed the independence between relational systems in anorexic patients. Dynamical analysis reveals that interactional patterns are internalized through the temporal organization of autobiographical speech. Moreover, these results support the existence of a specific temporal organization in anorexic adolescents' life

*Corresponding author. URECA, Université Lille 3, Villeneuve d'Ascq, France.
E-mail address: jean-louis.nandrino@univ-lille3.fr (J.-L. Nandrino).

[1] Now at the Laboratoire de Neurosciences Intégratives et Adaptatives (CNRS UMR 6149), Université de Provence, Marseille, France.

0732-118X/$ - see front matter
doi:10.1016/j.newideapsych.2007.07.004

narratives which express the internalization of stationary family patterns and indicate relative inability to disengage from active previous relational patterns and to create new ones.

1. Introduction

The etiology of anorexia nervosa implies several factors including biological, cultural, personality, and family ones (Beumont, Russel, & Touyz, 1993; Garfinkel & Garner, 1982). In fact, positive response to family therapy (Eisler et al., 2000; Herscovici & Bay, 1996; Martin, 1985; North, Gowers, & Byram, 1997) leads to consider the family organization as an important factor in the disposition and maintenance of anorexia nervosa. Indeed, the organization of anorexic patients' family can be studied either through the direct observation of the interaction pattern or through patients' narrations as an expression of an interactional model (Benoit & Parker, 1994; Gerlsman & Luteijn, 2000).

Direct inspection showed that the onset and maintenance of anorexia nervosa are related to a specific pattern of rigid interactions (Kog & Vandereycken, 1989; McDermott, Batik, Roberts, & Gibbon, 2002; Minuchin, Baker, Rosman, Milman, & Todd, 1975; Minuchin, Rosman, & Baker, 1978). Anorexic families are characterized by overprotection, enmeshment (Karwautz et al., 2003; Laporte, Marcoux, & Guttman, 2001; Minuchin et al., 1978) and a deficit in the expression of feelings (Palmer, Oppenheimer, & Marshall, 1988; Stern et al., 1989). In addition, less tension and conflict were observed in anorexic as compared to bulimic families (Garner, Garfinkel, & O'Shaughnessy, 1985; Strober, 1981). Moreover, anoxeric family members avoid conflict or lack conflict resolution abilities (Casper & Troiani, 2001; Kog & Vandereycken, 1988, 1989; Latzer & Gaber, 1998; Minuchin et al., 1978; Strober, 1981). Conflict avoidance is reflected in a low level of criticism and hostility in anorexic patients' relatives (Dare, LeGrange, Eisler, & Rutherford, 1994), while poor conflict resolution is often indicated by a confrontational interaction style (Lattimore, Wagner, & Gowers, 2000). The repetition of these transactional patterns helps maintaining homeostasis in the family system but decreases family members' adaptive abilities to cope with internal or external stressful events (Minuchin et al., 1975, 1978; Pauzé, Charbouillot-Mangin, & Saint-Pierre, 1996).

Indirect inspection of interaction models in the narratives is inspired by attachment theories (Bowlby, 1969, 1973, 1980; Dallos, 2001; Main, Kaplan, & Cassidy, 1985) which maintain that the patterns of family interactions are internalized in a working model. Such an internal model can then emerge in the content and the style of the patients' narratives. These studies on attachment relationships have been conducted through the analysis of early family experiences as reported in the adult attachment interview (AAI) (Benoit & Parker, 1994; Main et al., 1985).

The content and structure of these semistructured interviews contain meaningful indicators of adolescent anorexic's internalization and interactional patterns (Allen, Hauser, & Borman-Spurrell, 1996; Kobak, Cole, Ferenz-Gillies, & Fleming, 1993; Rosenstein & Horowitz, 1996; Zimmermann, 2004). Such patterns are characterized by a preponderance of insecure attachment (Candelori & Ciocca, 1988; Ward, Ramsay, & Treasure, 2000; Ward et al., 2001) which is associated with poor and critical relationships with the father (Cole-Detke & Kobak, 1996), and with emotional inconsistency (Salzman, 1997), intrusive behaviors, and lack of maternal care (O'Kearney, 1996).

Since AAI is designed to elicit childhood memories of the interactions with the parents, the data analyzed with AAI are mainly autobiographical narratives (Wahlers & Castlebury, 2002). Autobiographical narratives are summaries of long-term and recent events describing social contingencies in the narrator's relationships (McAdams, 1993, 2001; Nelson, 1988; Wahlers & Castlebury, 2002; Welch-Ross, 1995) and her/his perception of her/his relational systems (Steffen, 1997). Life narratives allow individuals to organize recollective memories (Brewer, 1996), and more abstract knowledge of their past into a coherent biographical view (Habermas & Bluck, 2000). The autobiographical narrative can be analyzed along different levels: temporal coherence, cultural concept of biography, thematic coherence, and causal coherence (Bluck & Habermas, 2001; Habermas & Bluck, 2000). Temporal coherence refers to the ability to report events in their chronological order. Life history follows a temporal order, mimicking the flow of time by presenting initially what has happened first in time. Cultural concept of biography refers to knowledge of the normative and salient events that might occur during the course of life. Thematic coherence involves the ability to step back from recalled experiences and extract metaphors, lessons, or messages. Finally, causal coherence refers to the individual's understanding of explanations and motives behind the life events they recall (Bluck & Habermas, 2001; Fromholt & Larsen, 1991; Luborsky, 1990).

The qualitative analysis of autobiographical narratives in addictive patients (alcohol, sex, drugs, gambling, and eating disorders) shows patterns of social and family interactions specifically related to the nature of the addiction (Hanninen & Koski-Janes, 1999). In particular, in adolescents with eating disorders, interpersonal relationships are mainly characterized by the parents' indifference, friends' abandon, ashamed social isolation, and self-disgust. The analysis of narratives relating life experiences with people other than parents in bulimic patients revealed that patients feel negatively not only about their body and themselves but also about the support and care they received from their families (Benninghoven, Schneider, Strack, Reich, & Cierpka, 2003).

Traditionally, such narrative processes have been tackled by an analysis of their symbolic content, while other important aspects such as their temporal organization have been ignored. Although language processing clearly unfolds over time, language representations produced by traditional models typically have a static quality (Elman, 1995). Because of its inherent temporal dimension, speech can be considered as a dynamic self-organized phenomenon (Elman, 1995; Zellner Keller & Keller, 2000), and can be studied using concepts and numerical methods borrowed from non-linear dynamics. Non-linear dynamics allows one to study complex time-varying phenomena (Kaplan & Glass, 1995), and offers a more holistic approach to the study of mental illness (Ehlers, 1995; Pezard & Nandrino, 2001). Within this framework, mental illness can be considered as a dynamical process, which can be observed at the physiological and at the language level, e.g. the dynamical study of speech in schizophrenia shows a specific temporal organization characterized by a deficit in the maintenance of discourse plan (Leroy, Pezard, Nandrino, & Beaune, 2005).

We study autobiographical speech of anorexic adolescents as a dynamical phenomenon with methods used to study non-linear dynamical phenomena. The purpose of this study is (1) to show that the interactional patterns expected to be internalized in anorexia nervosa can be studied through the dynamical characteristics of autobiographical speech, particularly of components related to the personal relationships (family, love, social, etc.); (2) to characterize the temporal organization of the narrative components of autobiographical speech.

2. Methods

2.1. Participants

A group of 27 subjects participated in the study: 14 young women (mean age: 19.23 years, SD: 1.96) meeting the DSM-IV criteria for anorexia nervosa restrictive type i.e. without the binge-eating and vomiting, or laxative abuse of bulimics (American Psychiatric Association, 1994), constituted our patient group and 13 young women (mean age: 20.5 years, SD: 1.87) who paired for educational level with the patients constituted our control group. Mean age does not differ significantly between anorexic patients and control subjects (Mann–Whitney test, $U = 54.5$, $p = 0.077$).

Semistructured interviews were used to obtain details of the history and clinical manifestations of the illness. Anorexic patients had a body mass index (BMI) ranging from 12 to 15.5 (mean: 13.9, SD: 1.14) and illness duration ranging from 1 to 4 years (mean: 2.5, SD: 1.02). Seven patients were treated with anti-depressant drugs (serotoninergic agonists) in order to decrease the eating obsessions. Diagnostic assignment was determined by the consensual judgment of three professionals (one psychiatrist and two clinical psychologists). None of the control subjects had any previous history of psychiatric disorders, drug abuse, eating, or personality disorders (axis II of the DSM-IV).

2.2. Data acquisition

Autobiographical narratives were obtained from anorexic and control subjects by asking them the question: ''Can you tell me the story of your life?'' (Hanninen & Koski-Janes, 1999; Von Wyl, 2000). The interviewer intervened as rarely as possible and only asked questions to resume the speech after a silence of at least 10 s. In order to avoid orienting patient's speech, the interviewer's questions always repeated the theme preceding the silence in subject's narratives. The interview stopped when the subject felt she has nothing more to say. Each autobiographical interview was audio-taped on-line and transcribed off-line for further analysis by a human operator on a text editor.

2.3. Data encoding

In order to perform quantitative analysis of the autobiographical speech, the narratives were encoded according to the semantic components expressing interpersonal relationships. Each autobiographical speech was divided into 5-s segments and each of these segments was assigned either a speech or a silence symbol (Si) (Rapp, Jimenez-Montano, Langs, Thomson, & Mees, 1991; Schiepek et al., 1997). A 5-s period was selected in order to optimize both the length of the symbolic sequences and the follow-up of the language time scale.

In a second step, the segments with ''speech symbol'' were associated to semantic code according to the linguistic content of the segment. The semantic components of life narratives were encoded according to four categories of interpersonal relations: family relations (FR), social relations (SR), love relations (LR), and self-reference (Se). Each semantic category was defined by precise inclusion criteria:

Family relations: Referred to family functioning, interactional, and emotional communication in the family system, myth, and beliefs of family, and family story. Example: "My parents are alone since 1995."

Social relations: Referred to relations with the friends, interaction, and emotional communications in the SR, self-esteem, cultural models, and religious beliefs. Example: "My one fear is that I might disappoint my best friend."

Love relations: Referred to sexuality, romantic life, love-making, love relationships, interactional, and emotional communication in the LR sexed body. Example: "I'm madly in love."

Self-reference: Referred to metacommunication on one's life history. Example: "My life is very simple".

The encoding procedure was tested for inter-rater agreement. Five autobiographical narratives, out of a total of 27, were independently encoded by three clinical psychologists. The κ-coefficients of inter-rater agreement (range: 0.80–0.92, median: 0.83) were considered satisfactory (Fliess, 1981).

The length of the autobiographical narrative was measured by the total number of the speech and silence symbols which each corresponds to a 5-s temporal interval. Autobiographical narratives did not significantly differ in length between anorexic patients and control subjects (anorexics: mean: 576 symbols, SD: 37.67; controls : mean: 568, SD: 55.89; Mann–Whitney test, $U = 86.5$, $p = 0.827$).

2.4. Data analysis

The encoding procedure based on the above-mentioned categories (FR, SR, LR, Se) and silences (Si) yielded symbolic sequences denoting the temporal organization of linguistic components for each subject. Static and dynamical characteristics of these sequences were then analyzed. Adapted non-parametric statistical procedures were used to test the statistical significance of our results. We now provide a qualitative description of the methods (see Appendix A for technical details).

2.4.1. Static index

The static structure of the symbolic sequences was characterized by the frequency of each of the 5 semantic components (see Appendix A Eq. (1)).

2.4.2. Dynamical indices

Static descriptions of sequences may miss information embodied in their temporal sequence. To check for the presence of temporal structure in the encoded sequences of semantic components, several dynamical indices were computed using information theory (Shannon, 1948), symbolic dynamics (Badii & Politi, 1997), and Markov models formalism (Gardiner, 2004).

The overall temporal structure was characterized using the one time step "mutual information" (denoted by I; see Appendix A, Eq. (2)). This index measures the non-linear probabilistic correlation between two successive symbols. Statistical independence corresponds to $I = 0$.

First, we statistically tested the presence of a temporal structure in the experimental data. We then compared the values of I obtained for the experimental symbolic sequence with those obtained for a set of 999 "surrogate data" for each participant

(Schreiber & Schmitz, 2000). Surrogate data were obtained by shuffling the experimental data so that both sets of data (experimental and surrogate) shared the same "static index". We considered that the experimental data contained significant temporal structure if the number of surrogate data for which $I(\text{sur}) < I(\text{exp})$ was higher than 950. This procedure corresponds to a one-sided bootstrap test with a $p = 0.05$ statistical threshold.

A detailed analysis of the transitions between semantic component to another was based on a Markov model of the symbolic sequence. Namely, transition probabilities from one symbol to another were computed (leading to a matrix of transition probabilities; see Appendix A Eq. (3)). The transition rate from the first symbol to the second can be obtained by multiplying the transition probability by the first symbol's frequency. The difference between this rate and the reverse one measures the presence and sign of a "probability current" (see Appendix A, Eq. (5)). These probability currents were used both as a global index, the sum of the currents (denoted by Σ), and as local indices, the individual currents (denoted by c_{ij}). The magnitude of the currents' sum measure the system's distance from equilibrium, where the sum of the currents is null ($\Sigma = 0$).

3. Results

3.1. Frequential analysis

The results of the frequency analysis are summed up in Fig. 1. In both groups, the "Se" and "silence" codes were less represented than the other semantic components. Anorexic

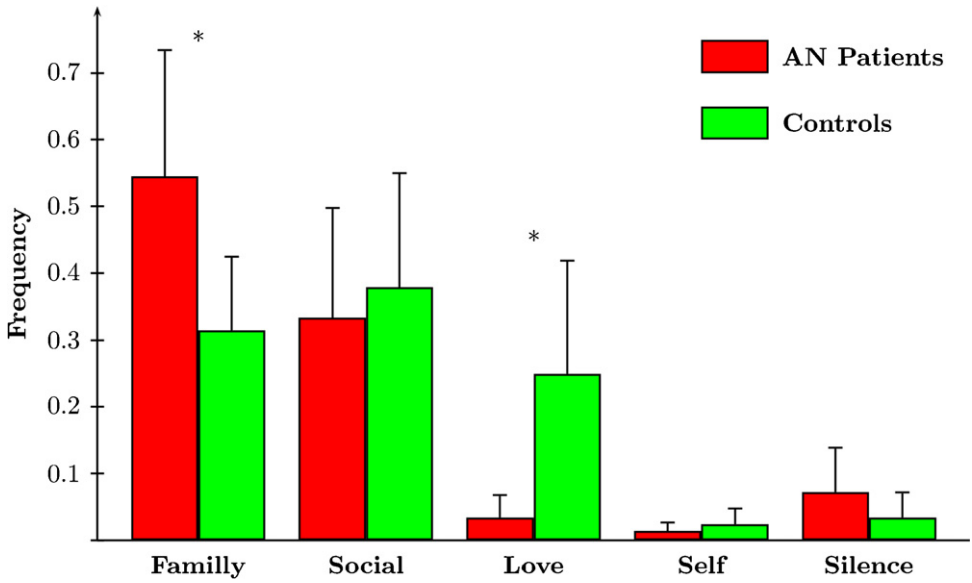

Fig. 1. Averaged frequencies of each semantic component for anorexia group (AN patients) and the control group (controls). SD are depicted as vertical bars. Stars denote the statistical differences between groups.

patients and control participants did not differ regarding "Se" (anorexics: mean: 0.014, SD: 0.01; controls: mean: 0.024, SD: 0.024; Mann–Whitney test, $U = 75$, $p < 0.437$). Nevertheless, anorexic patients tended to produce more silences than controls (anorexics: mean: 0.072, SD: 0.068; controls: mean: 0.034, SD: 0.039; Mann–Whitney test, $U = 52$, $p = 0.058$).

The three other components ("FR", "LR", and "SR") were equally represented in controls' speech (Friedman test, $X^2 = 2$, $p = 0.368$), but had an heterogeneous distribution in patients' speech (Friedman test, $X^2 = 22.75$, $p < 0.001$; Wilcoxon test: family vs. social: $W = 76$, $p = 0.03$; family vs. love: $W = 105$, $p = 0.001$; love vs. social: $W = 105$, $p = 0.001$).

Anorexic patients' speech was significantly more focused on "FR" than that of control participants (anorexics: mean: 0.545, SD: 0.191; controls: mean: 0.315, SD: 0.111; Mann–Whitney test, $U = 22.5$, $p < 0.01$) and significantly avoided "LR" (anorexics : mean: 0.034, SD: 0.034; controls: mean: 0.249, SD: 0.171; Mann–Whitney test, $U = 10.5$, $p < 0.01$). Nevertheless, anorexic patients and control participants did not differ regarding "SR" (anorexics: mean: 0.334, SD: 0.165; controls: mean: 0.379, SD: 0.172; Mann–Whitney test, $U = 45$, $p < 0.09$).

3.2. Dynamical analysis

3.2.1. Presence of time structure (temporal succession between the symbols)

For all subjects, the "mutual information" values obtained for a set of 999 surrogate data were significantly lower than those for the experimental sequence ($p = 0.05$). These results point to a significant temporal structure in the original data and to the insufficiency of frequency analysis.

3.2.2. Predictability of the temporal dynamics (intensity of the relation between two successive symbols)

"Mutual information" values for the anorexic patients were significantly lower than those of control subjects (anorexics: mean: 0.524, SD: 0.083; controls: mean: 0.782, SD: 0.084; Mann–Whitney test, $U = 8$, $p < 0.001$). This result indicates a lower short-term correlation between symbols in anorexics speech's temporal organization.

3.2.3. Dynamical transitions (symmetry of the transitions from one symbol to another)

"The sum of probability currents" (Σ) was significantly lower for the anorexic patients than for control subjects (anorexics: mean: 0.006, SD: 0.008; controls: mean: 0.015, SD: 0.011; $U = 41.5$, $p < 0.016$). This result shows that anorexic patients' speech is characterized by semantic transitions which are more symmetric than the ones of the control group. Thus, the patients' semantic dynamics is closer to equilibrium than that of controls.

To highlight a possible specific structure of the patients' speech, "the probability currents" were individually analyzed. The analysis of the "probability currents" showed significant differences in the patterns of dynamical transitions (Fig. 2 and Table 1). The "probability current" values of the transitions "family–social", "family–love", "social–love", "social–Se", and "love–Se" were significantly lower for the anorexic patients than those of the control subjects.

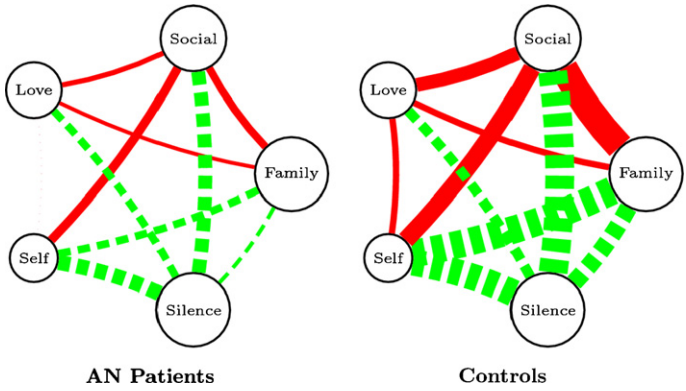

Fig. 2. Averaged absolute values of the probability currents for anorexia group (AN patients) and the control group (controls). The lines represent the probability currents between the semantic components. Solid lines depict the currents for which statistical differences have been observed (no difference has been observed for the currents in dashed lines). The intensity of the current is encoded in the thickness of the lines.

Table 1
Averaged values and statistical results for the comparisons between anorexic patients and control subjects for the intensities of probability currents

	AN patients	Controls	Wilcoxon rank sum test
Fam.–Soc.	**0.64 (1.39)**	**2.23 (2.09)**	$W = \mathbf{143.5}$, $p = \mathbf{0.01}$
Fam.–Lov.	**0.29 (0.73)**	**0.46 (0.78)**	$W = \mathbf{136}$, $p = \mathbf{0.02}$
Fam.–Self.	0.57 (0.85)	2.23 (2.49)	$W = 123.5$, $p = 0.10$
Fam.–Sil.	0.29 (0.73)	0.85 (1.39)	$W = 131$, $p = 0.05$
Soc.–Lov.	**0.43 (0.85)**	**1.08 (1.32)**	$W = \mathbf{142}$, $p = \mathbf{0.01}$
Soc.–Self.	**0.71 (1.90)**	**1.46 (1.56)**	$W = \mathbf{133}$, $p = \mathbf{0.03}$
Soc.–Sil.	1.07 (1.44)	2.38 (2.79)	$W = 122.5$, $p = 0.12$
Lov.–Self.	**0.00 (0.00)**	**0.46 (0.78)**	$W = \mathbf{119}$, $p = \mathbf{0.03}$
Lov.–Sil.	0.64 (1.08)	0.77 (1.30)	$W = 100$, $p = 0.67$
Self.–Sil.	1.25 (1.60)	2.08 (3.09)	$W = 89$, $p = 0.56$

In bold: significant differences. SD are given in the parenthesis. "Fam.": family relations, "Soc.": social relations, "Lov.": love relations, "Self.": self-reference, "Sil.": silence.

4. Discussion and perspectives

4.1. Dynamical methods

The results showed that the "mutual information" values obtained for a set of 999 surrogate data were significantly lower than that of the experimental data. These results thus show the presence of a significant temporal structure in the experimental data. This temporal organization of the semantic components observed in both groups confirms our previous results (Leroy et al., 2005) and emphasizes the importance of a dynamical characterization of speech as a complement to static descriptions. This result suggests that autobiographical narratives are dynamic phenomena that can self-organize without direct intervention of an interlocutor. The dynamics of the semantic components reveals

the narrative's global organization and appears as a powerful index of healthy and pathological states.

One of the main interests of our study is to show that autobiographical speech can be characterized quantitatively via mathematical tools borrowed from non-linear time-series analysis (Habermas & Bluck, 2000). Our study further shows that temporal coherence is not solely constructed on dates, or on a few highly significant events, but also according to the narratives of the relational systems.

Dynamic analysis can also help characterizing intra-subjective dynamics in different interpersonal contexts. As in attachment theory, our results suggest that the patterns of family interactions are internalized in models which reappear in the content and style of patients' narratives. In this perspective, interactional patterns are also internalized through dynamical constraints on the speech components. The subjective representation of relational systems is not only structured at the semantic level but can also be observed in the temporal organization of these components. The temporal organization of speech can be described at different time scales: a long time scale with slow dynamics corresponding to the sequences of life events, a medium time scale corresponding to sequences of transactional patterns, and a short time scale with rapid dynamics corresponding to relations between components of the speech.

4.2. Psychopathological interpretation and scope

The static characteristics of anorexic patients' autobiographical speech show a high representation of FR and a low representation of LR whereas a homogeneous representation of LR, FR, and SR is observed for control girls. These data support the clinical observations of negative or threatening feelings and attitudes of anorexic adolescents towards sexuality and LR (Morgan, Wiederman, & Pryor, 1995; Raboch & Faltus, 1991; Ruuska, Kaltiala-Heino, Koivisto, & Rantanen, 2003; Wiederman, Pryor, & Morgan, 1996) which is accentuated during the anorexic episode (Tuiten et al., 1993). Poor investment in LR and hyper-investment in FR are linked in anorexic adolescents: the focus on FR is maintained or reinforced by the absence of LR and vice versa (Basseches & Karp, 1984; Bruch, 1973; Buhrmester, 1990; Crisp, 1980; Rice & Mulkeen, 1995; Smolak & Levine, 1993; Wechselblatt, Gurnick, & Simon, 2000). In contrast, control adolescents organize their life history using all relational dimensions (social, love, familial, and auto-reference) which allows them a larger variety of scenario.

The dynamical indices showed that the temporal organization of autobiographical speech differs between anorexic patients and control subjects:

1. "Mutual information" indices show that the temporal organization of the semantic component is less predictable in patients than in controls. This result characterizes the independence between relational systems internalized in narratives in anorexic patients. In control subjects, the higher coherence and the stronger link between the expressed relational systems moreover supports the results obtained with static measures.
2. "The sum of probability currents" was significantly lower for the anorexic patients than for control subjects. This result indicates that the transitions between semantic categories are more symmetric in anorexic patients than in controls. This symmetry between the symbols could correspond to the existence of stationary patterns in the

patients with anorexia nervosa. In other words, the narratives of anorexic patients are closer to a statistical equilibrium than that of the controls.

Finally, "the sum of probability currents", which is lower for anorexic patients than for control subjects, could characterize a relative independence from external environment in the temporal dynamics of anorexic narratives. This independence from external perturbations could be related to the controlled mode of information processing observed in their cognitive activity (Dodin & Nandrino, 2003; Green, Elliman, Wakeling, & Rogers, 1996; Otagaki, Tohoda, Osada, Horiguchi, & Yamawaki, 1998; Strupp, Weingartner, Kaye, & Gwirstman, 1986). Studies of cognitive activity in eating disorders have underlined the difficulty of patients to learn new strategies (Green et al., 1996) and to treat new stimuli according to their contextual task-related relevance (Dodin & Nandrino, 2003).

Since internalization of transactional patterns is a dynamical process that can be modified by external or internal constraints, it could be particularly interesting to study how such temporal organization evolves after recovery i.e. whether these patients keep the same organization in their life history or not.

Acknowledgments

This study benefits from the financial support of French Ministry of Research and CNRS through the "Action Concertée Incitative: Systèmes Complexes en Sciences Humaines et Sociales". The authors thank David Papo for his comments and his help for the translation.

Appendix A. Mathematical methods

For a subject k, the autobiographical speech is encoded according to five symbols (FR, SR, LR, Se. and Si) leading to a symbolic sequence of length N: $S_k = \{s_i(n)\}$ for $s_i \in FR, SR, LR, Se, Si$ and $n = 1, \ldots, N$.

The frequency of a symbol is than defined as

$$f_k(s_i) = \frac{\neq(s_i)}{N}, \tag{1}$$

where $\neq(s_i)$ denotes the number of s_i in S_k.

The mutual information is defined as

$$I_k = \sum_{s_i(n)} \sum_{s_i(n+1)} p(s_i(n), s_j(n+1)) \log \frac{p(s_i(n), s_j(n+l))}{p(s_i(n))p(s_j(n+1))}, \tag{2}$$

where $p(\cdot)$ denotes the probability of "$\cdot$". In our case, the probabilities were taken as the frequencies of each symbol ($p(s_i) \approx f(s_i)$) or of each two-word ($p(s_i, s_j) \approx f(s_i, s_j)) = \neq(s_i s_j)/(N-1)$.

The transition matrix T is defined as $T = |T_{ij}|$ where

$$T_{ij} = p(s_j(n+1)|s_i(n)). \tag{3}$$

Here, $p(s_j(n+1)|s_i(n))$ is estimated as follows:

$$p(s_j(n+1)|s_i(n)) \approx \frac{\neq(s_i s_j)}{\neq(s_i)} \tag{4}$$

with the same notations as for the frequency definition.

The current matrix is defined as $C = [C_{ij}]$ where

$$C_{ij} = p(s_i)T_{ij} - p(s_j)T_{ji}. \quad (5)$$

References

Allen, J., Hauser, S., & Borman-Spurrell, E. (1996). Attachment theory as a framework for understanding sequelae of severe adolescent psychopathology: An 11-year follow-up. *Journal of Consulting and Clinical Psychology*, *64*(2), 254–263.

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders DSM-IV*. Washington: American Psychiatric Association.

Badii, R., & Politi, A. (1997). *Complexity. Hierarchical structures and scaling in physics*. Cambridge: Cambridge University Press.

Basseches, H., & Karp, S. (1984). Field dependence in young anorectic and obese women. *Psychotherapy and Psychosomatics*, *41*, 33–37.

Benninghoven, D., Schneider, H., Strack, M., Reich, G., & Cierpka, M. (2003). Family representations in relationship episodes of patients with a diagnosis of bulimia nervosa. *Psychology and Psychotherapy: Theory, Research and Practice*, *76*, 323–336.

Benoit, D., & Parker, K. (1994). Stability and transmission of attachment across three generations. *Child Development*, *65*, 1444–1456.

Beumont, P., Russel, J., & Touyz, S. (1993). Treatment of anorexia nervosa. *The Lancet*, *26*, 341–346.

Bluck, S., & Habermas, T. (2001). Extending the study of autobiographical memory: Thinking back about life across the life span. *Review of General Psychology*, *5*(2), 135–147.

Bowlby, J. (1969). *Attachment and loss*, Vol. 1. New York: Basic Books.

Bowlby, J. (1973). *Attachment and loss. Separation, anxiety and anger*, Vol. 2. New York: Basic Books.

Bowlby, J. (1980). *Attachment and loss. Sadness and depression*, Vol. 3. New York: Basic Books.

Brewer, W. (1996). What is recollective memory? In D. Rubin (Ed.), *Remembering our past: Studies in the autobiographical memory*. Cambridge: Cambridge University Press.

Bruch, H. (1973). *Eating disorders: Obesity, anorexia nervosa, and the person within*. New York: Basic Books.

Buhrmester, D. (1990). Intimacy of friendship, interpersonal competence, and adjustment during preadolescence and adolescence. *Child Development*, *61*, 1101–1111.

Candelori, C., & Ciocca, A. (1988). Attachment and eating disorders. In P. Bria, A. Ciocca, & S. De Risio (Eds.), *Attachment and Eating disorders*. Rome: Societa Editrice Universo.

Casper, R., & Troiani, M. (2001). Family functioning in anorexia nervosa differs by subtype. *International Journal of Eating Disorders*, *30*, 338–342.

Cole-Detke, H., & Kobak, R. (1996). Attachment process in eating disorder and depression. *Journal of Consulting and Clinical Psychology*, *64*(2), 282–290.

Crisp, A. (1980). *Anorexia nervosa: Let me be*. London: Academic Press.

Dallos, R. (2001). Attachment narrative therapy: Narrative and attachment approaches in systemic family therapy with eating disorders. *Journal of Family Psychotherapy*, *12*(2), 43–72.

Dare, C., LeGrange, D., Eisler, I., & Rutherford, J. (1994). Redefining the psychosomatic family: Family process of 26 eating disorder families. *International Journal of Eating Disorders*, *16*(3), 211–226.

Dodin, V., & Nandrino, J. (2003). Cognitive processing of anorexic patients in recognition tasks: An event-related potentials study. *International Journal of Eating Disorders*, *33*, 1–9.

Ehlers, C. (1995). Chaos and complexity. Can it help us to understand mood and behavior? *Archives of General Psychiatry*, *52*, 960–964.

Eisler, I., Dare, C., Hodes, M., Russell, G., Dodge, E., & Le Grange, D. (2000). Family therapy for adolescent anorexia nervosa: The results of a controlled comparison of two family interventions. *Journal of Child Psychology and Psychiatry*, *41*(6), 727–736.

Elman, J. L. (1995). Language as a dynamical system. In R. Port, & T. Van Gelder (Eds.), *Mind as motion* (pp. 195–225). Cambridge, MA: MIT Press.

Fliess, J. (1981). Balanced incomplete block designs for inter-rater reliability studies. *Applied Psychological Measurement*, *5*, 105–112.

Fromholt, P., & Larsen, S. (1991). Autobiographical memory in normal aging and primary degenerative dementia. *Journal of Gerontology: Psychological Sciences*, *46*, 85–91.

Gardiner, C. W. (2004). *Handbook of stochastic methods for physics, chemistry and the natural sciences* (3rd ed.). Heidelberg: Springer.

Garfinkel, P., & Garner, D. (1982). *A multidimensional perspective*. New York: Brunner/Mazel.

Garner, D., Garfinkel, P., & O'Shaughnessy, M. (1985). The validity of the distinction between bulimia with and without anorexia nervosa. *American Journal of Psychiatry*, *142*, 581–587.

Gerlsman, C., & Luteijn, F. (2000). Attachment style in the context of clinical and health psychology: A proposal for the assessment of valence, incongruence, and accessibility of attachment representations in various working models. *British Journal of Medical Psychology*, *73*(1), 15–34.

Green, M., Elliman, N., Wakeling, A., & Rogers, P. (1996). Cognitive functioning, weight change and therapy in anorexia nervosa. *Journal of Psychiatric Research*, *30*, 401–410.

Habermas, T., & Bluck, S. (2000). Getting a life: The emergence of the life story in adolescence. *Psychological Bulletin*, *126*(5), 748–769.

Hanninen, V., & Koski-Janes, A. (1999). Narratives of recovery from addictive behaviours. *Addiction*, *94*(12), 1837–1848.

Herscovici, C., & Bay, L. (1996). Favourable outcome for anorexia nervosa patients treated in argentina with a family approach. *Eating Disorders*, *4*, 59–66.

Kaplan, D., & Glass, L. (1995). *Understanding nonlinear dynamics*. New York: Springer.

Karwautz, A., Nobis, G., Haidvogl, M., Wagner, G., Hafferl-Gattermayer, A., Wober-Bingol, C., et al. (2003). Perception of family relationships in adolescents with anorexia nervosa and their unaffected sisters. *European Child and Adolescent Psychiatry*, *12*(3), 128–135.

Kobak, R., Cole, H., Ferenz-Gillies, R., & Fleming, W. (1993). Attachment and emotion regulation during mother–teen problem solving: A control theory analysis. *Child Development*, *64*, 231–245.

Kog, E., & Vandereycken, W. (1988). The family approach to eating disorders. In E. Kog, & J. Vanderlinden (Eds.), *Assessment and treatment of anorexia and bulimia*. New York: Basic Books.

Kog, E., & Vandereycken, W. (1989). Family interaction in eating disorder patients and normal controls. *International Journal of Eating Disorders*, *8*(1), 11–23.

Laporte, L., Marcoux, V., & Guttman, H. (2001). Caractéristiques des familles de femmes présentant un trouble d'anorexie mentale restrictive comparées à celles de familles témoins. *L'Encéphale*, *XXVII*, 109–119.

Lattimore, P., Wagner, H., & Gowers, S. (2000). Conflict avoidance in anorexia nervosa: An observational study of mothers and daughters. *European Eating Disorders Review*, *8*, 355–368.

Latzer, Y., & Gaber, L. (1998). Pathological conflict avoidance in anorexia nervosa: Family perspectives. *Contemporary Family Therapy*, *20*(4), 539–551.

Leroy, F., Pezard, L., Nandrino, J.-L., & Beaune, D. (2005). Dynamical quantification of schizophrenic speech. *Psychiatry Research*, *133*, 159–171.

Luborsky, M. (1990). Alchemists' visions: Cultural norms eliciting and analyzing life narratives. *Journal of Aging Studies*, *4*, 17–29.

Main, M., Kaplan, N., & Cassidy, J. (1985). Security in infancy, childhood and adulthood: A move to the level of representation. Growing points in attachment: Theory and research. *Monographs of the Society for Research in Child Development*, *50*(209), 66–104.

Martin, F. (1985). The treatment and outcome of anorexia nervosa in adolescents: A prospective study and five year follow-up. *Journal of Psychiatric Research*, *19*, 509–514.

McAdams, D. (1993). *The stories we live by: Personal myths and the making of the self*. New York: Morrow.

McAdams, D. (2001). The psychology of life stories. *Review of General Psychology*, *5*(2), 100–122.

McDermott, B., Batik, M., Roberts, L., & Gibbon, P. (2002). Parent and child report of family functioning in a clinical child and adolescent eating disorders sample. *Australian and New Zealand Journal of Psychiatry*, *36*, 509–514.

Minuchin, S., Baker, B., Rosman, B., Milman, L., & Todd, T. (1975). A conceptual model of psychosomatic illness in children: Family organization and family therapy. *Archives of General Psychiatry*, *32*, 1031–1038.

Minuchin, S., Rosman, B., & Baker, B. (1978). *Psychosomatic families: Anorexia nervosa in context*. Cambridge, MA: Harvard University Press.

Morgan, C. D., Wiederman, M. W., & Pryor, T. L. (1995). Sexual functioning and attitudes of eating-disordered women follow-up study. *Journal of Sex and Marital Therapy*, *21*(2), 67–77.

Nelson, K. (1988). The ontogeny of memory for real events. In U. Neisser, & E. Winograd (Eds.), *Remembering reconsidered*. New York: Cambridge University Press.

North, C., Gowers, S., & Byram, V. (1997). Family functioning and life events in the outcome of adolescent anorexia nervosa. *British Journal of Psychiatry*, *171*, 545–549.

O'Kearney, R. (1996). Attachment disruption in anorexia nervosa and bulimia nervosa: A review of theory and empirical research. *International Journal of Eating Disorders*, *20*(2), 115–127.

Otagaki, Y., Tohoda, Y., Osada, M., Horiguchi, J., & Yamawaki, S. (1998). Prolonged p300 latency in eating disorders. *Neuropsychobiology*, *37*, 5–9.

Palmer, R., Oppenheimer, R., & Marshall, P. (1988). Eating-disordered patients remember their parents: A study using the parental-bonding instrument. *International Journal of Eating Disorders*, *7*(1), 101–106.

Pauzé, R., Charbouillot-Mangin, B., & Saint-Pierre, F. (1996). Perspective multifactorielle interactionniste et diachronique de l'anorexie. *Thérapie Familiale, Genève*, *17*(2), 241–259.

Pezard, L., & Nandrino, J. (2001). Paradigme dynamique en psychopathologie: la ''théorie du chaos,'' de la physique à la psychiatrie. *L'Encéphale*, *XXVII*, 260–268.

Raboch, J., & Faltus, F. (1991). Sexuality of women with anorexia nervosa. *Acta Psychiatrica Scandinavica*, *84*(1), 9–11.

Rapp, P., Jimenez-Montano, M., Langs, R., Thomson, L., & Mees, A. (1991). Toward a quantitative characterization of patient–therapist communication. *Mathematical Biosciences*, *105*(2), 207–227.

Rice, K., & Mulkeen, P. (1995). Relationships with parents and peers: A longitudinal study of adolescent intimacy. *Journal of Adolescent Research*, *110*, 338–357.

Rosenstein, D., & Horowitz, H. (1996). Adolescent attachment and psychopathology. *Journal of Consulting and Clinical Psychology*, *64*(2), 244–253.

Ruuska, J., Kaltiala-Heino, R., Koivisto, A., & Rantanen, P. (2003). Puberty, sexual development and eating disorders in adolescent outpatients. *European Child and Adolescent Psychiatry*, *12*(5), 214–220.

Salzman, J. (1997). Ambivalent attachment in female adolescents: Association with affective instability and eating disorders. *International Journal of Eating Disorders*, *21*, 251–259.

Schiepek, G., Kowalik, Z., Schutz, A., Kohler, M., Richter, K., Strunk, G., et al. (1997). Psychotherapy as a chaotic process 1. Coding the client–therapist interaction by means of sequential plan analysis and the search for chaos: A stationary approach. *Psychotherapy Research*, *7*(2), 173–194.

Schreiber, T., & Schmitz, A. (2000). Surrogate time series. *Physica D*, *142*(3–4), 346–382.

Shannon, C. E. (1948). A mathematical theory of communication. *The Bell System Technical Journal*, *27*, 379–423.

Smolak, L., & Levine, M. (1993). Separation–individuation difficulties and the distinction between bulimia nervosa and anorexia nervosa in college women. *International Journal of Eating Disorders*, *14*(1), 33–41.

Steffen, V. (1997). Life stories and shared experience. *Social Science and Medicine*, *45*(1), 99–111.

Stern, S., Dixon, K., Jones, D., Lake, M., Nemzer, E., & Sansone, R. (1989). Family environment in anorexia nervosa and bulimia. *International Journal of Eating Disorders*, *8*(1), 25–31.

Strober, M. (1981). The significance of bulimia in juvenile anorexia nervosa: An exploration of possible etiologic factors. *International Journal of Eating Disorders*, *1*, 28–34.

Strupp, B., Weingartner, H., Kaye, W., & Gwirstman, H. (1986). Cognitive processing in anorexia nervosa. *Neuropsychobiology*, *15*, 84–94.

Tuiten, A., Panhuysen, G., Everaerd, W., Koppeschaar, H., Krabbe, P., & Zelissen, P. (1993). The paradoxical nature of sexuality in anorexia nervosa. *Journal of Sex and Marital Therapy*, *19*(4), 259–275.

Von Wyl, A. (2000). What anorexic and bulimic patients have to tell: The analysis of patterns of unconscious conflict expressed in stories about everyday events. *European Journal of psychotherapy, Counseling and Health*, *3*, 375–388.

Wahlers, R., & Castlebury, F. (2002). Personal narratives as maps of the social ecosystem. *Clinical Psychology Review*, *22*, 297–314.

Ward, A., Ramsay, R., & Treasure, J. (2000). Attachment research in eating disorders. *British Journal of Medical Psychology*, *73*, 35–51.

Ward, A., Ramsay, R., Turnbull, S., Steele, M., Steele, H., & Treasure, J. (2001). Attachment in anorexia nervosa: A transgenerational perspective. *British Journal of Medical Psychology*, *74*, 497–505.

Wechselblatt, T., Gurnick, G., & Simon, R. (2000). Autonomy and relatedness in the development of anorexia nervosa: A clinical case series using grounded theory. *Bulletin of the Menninger Clinic*, *64*(1), 91–123.

Welch-Ross, M. (1995). An integrative model of the development of autobiographical memory. *Developmental Review*, *15*, 338–365.

Wiederman, M., Pryor, T., & Morgan, C. (1996). The sexual experience of women diagnosed with anorexia nervosa or bulimia nervosa. *International Journal of Eating Disorders*, *19*(2), 109–118.

Zellner Keller,, B., & Keller,, E. (2000). The chaotic nature of speech rhythm: Hints for fluency in the language acquisition process. In P. Delcloque, & V. Holland (Eds.), *Integrating speech technology in language learning*. Swets and Zeitlinger.

Zimmermann, C. (2004). Attachment representation and characteristics of friendship relations during adolescence. *Journal of Experimental Child Psychology*, *88*, 83–101.