

Time Analysis on a Communication Process

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Abstract

The conversation is the most common interaction process in the daily life: the goal of this paper is the extraction of information on the evolution of a communicative process through simple quantitative measurements. The whole interview process has been considered as a complex system evolving in the time. Our approach founds on analogies between conversation processes and chaotic systems. The proposed procedure allowed the extraction of information on the conversation evolution: phase portraits with anomalous paths indicate situations where the communication has been troubled from external references. Some parameters showing very good indication on the process evolution are proposed.

Keyword: chaotic systems, communication analysis, feature extraction, cognitive system modeling , complex system

1 Introduction

We were born in essentially dialogic and linguistic universe and our whole relationship history is, also, a continuous learning of the art to cope with conversations in an effective way. Nevertheless, this process is unconscious: our senses are used to live what is manifest without any question. A reflection on an aspect usually regarded as obvious seems particularly interesting. What is self-evident escapes from inquiry; however its characteristic measurement, its components evaluation were the incentive and the aim of our work. Usually, our attention is focused on semantic meanings of pronounced words, but this automatic analysis is impossible actually. Our goal was to extract information on the evolution of a communicative process through simple quantitative measurements and with a particular attention to avoid any simplification form or classification. As in medicine blood analysis parameters can give an indication on the health state of a patient, our goal was to extract some measured indication on the "state" (correctness) of these interviews.

The theory of the communication process suggests some rules in the conduction of a psychological interview: it underlines the turn importance, the need of giving space to the interviewee, the weight of the usage of a uniform language. In practice, these

rules are often disregarded with negative effects on the interaction progress. The whole interview process has been considered as a complex system evolving in the time. In this paper we propose an analogy between conversations and chaotic systems: both of them are deterministic, non linear, predicable on the short time, not predictable on the long time, extremely sensible to the initial conditions. In both systems, time evolution shapes, defines and characterizes the process. As chaotic systems an interview is a complex phenomenon which complexity level cannot be simplified without the risk of fundamental information lost. Any cataloguing seems equivalent to the filtering application to a chaotic system: it can introduce orderliness or mechanisms linked to the filter, to the classifier, uncorrelated with the phenomenon under study.

2 Input Data: the Communication Processes

We analysed 1011 motivational research interviews made from university students of Psychology. They were supposed to conduct an interview to a colleague following the rules of psychological communication. They produced then a protocol that was a part of the examination within the course on Theory and Technique of the Psychological Conversation. Each protocol was composed by 3 parts:

1. a description of the setting and of the interviewer emotions before the interview depiction ;
2. a literal transcription of the conversation;
3. interviewer comments after the communication process.

The nature intrinsically interactive of the dialogue concretises, takes form and evolves within a temporal dimension. There is a reciprocal adaptation where each participant learns step by step to enter in the interlocutor's reference system, without quitting its own, until the construction of a common system exceeding those of both partner. We analysed the central part of the protocol.

The nature intrinsically interactive of the dialogue concretizes, shapes and evolves within time dimension. During the interaction, the turn alternation is fundamental, specially when the mutual definition of the relationship involves the acknowledgement of different roles. Since only written protocols were available, we took the number of word in each speech as unit.

3 Procedure: the Interview as a Time Process

Let A denote a compact finite-dimensional set of states in a system.

This set may consist of an equilibrium, periodic orbit, or chaotic attractor.

Let $g: A \rightarrow R$ be an observation function which is a measurement of some quantity of the system, and let τ be a real number greater than zero.

For each state $a \in A$, we can define the m -dimensional vector:

$$b = \{g(a), g[F_{-\tau}(a)], \dots, g[F_{-(m-1)\tau}(a)]\}$$

This vector is called a *delay coordinate vector* because its components consist of time-delayed versions of the observable of the system. It is an interesting fact that under quite reasonable conditions on the dynamics of the system F_t , this correspondence $D(a) = b$ is a one-to-one correspondence, as long as m is greater than twice the box-counting dimension of A , and the observation function g is chosen generically. This fact is called the *Fractal Delay Coordinate Embedding Prevalence Theorem* [1,2]. The vector b above is a segment of a time series with equally spaced data produced by the measurement function g .

That is, $b = [x_t, x_{t-\tau}, \dots, x_{t-(m-1)\tau}]$ where $x_t = g(a)$ is the value of the time series at time t and a is the state. Thus b is readily available. Any tangent manifold structure that exists on A is also carried over by the correspondence D .

In the original formulation of the theorem by Takens [1], A was assumed to be a smooth manifold but in Sauer, Yorke, and Casdagli [2] it is shown that more generally, if A is a fractal attractor, then not only does the one-to-one correspondence hold, but also any manifold structure that exists, such as an unstable manifold, is faithfully represented on $D(A)$. This motivates the belief, for example, that the positive Lyapunov exponents of A can be measured on the reconstructed set $D(A)$, even when A is fractal and not a smooth manifold.

The technique of delay coordinate reconstruction was introduced to reproduce the set of the system dynamic states by using a measured time series. We defined the vector of duration of each speech $[Q_1, A_1, Q_2, A_2, \dots, Q_n, A_n]$ Question 1, Answer 1, Question 2, Answer 2, ... Question n , Answer n].

This procedure allowed information extraction on the conversation evolution: plots with anomalous paths indicate situations where the communication has been troubled from external references. Some parameters defined as function of the phase portrait space occupancy give a very good indication on the process evolution and on the observance of the psychological interview laws

4 Results

We considered alternating turns as a distinctive element [3,5,6]. In figure 1 (a) the number of words uttered by the interviewer and by the interviewee are plotted with continuous and dot lines respectively. Differences in these plots give information about the duration of the turns. We considered the sequence development as a targeted behavior and we enlarged the elementary schema question/ answer in order to analyze the whole phenomenon.

In figure 1 (b) the ratio between the number of words articulated by the interviewer (question) and the number of words uttered by the interviewee (answer) are plotted. Differences in these plots give information about the time "space" the interviewer left to the interviewee. Long rate at the beginning can indicate the presence of an introduction to the interview. In figure 1 (c) the ratio between the number of words said by the interviewee (answer) and the number of words uttered by the interviewer (following

question) are plotted. This plot allows the extraction of other information on the process: for example, a large rate at the end can indicate the presence of a 'restitution phase'.

Interview nr.23

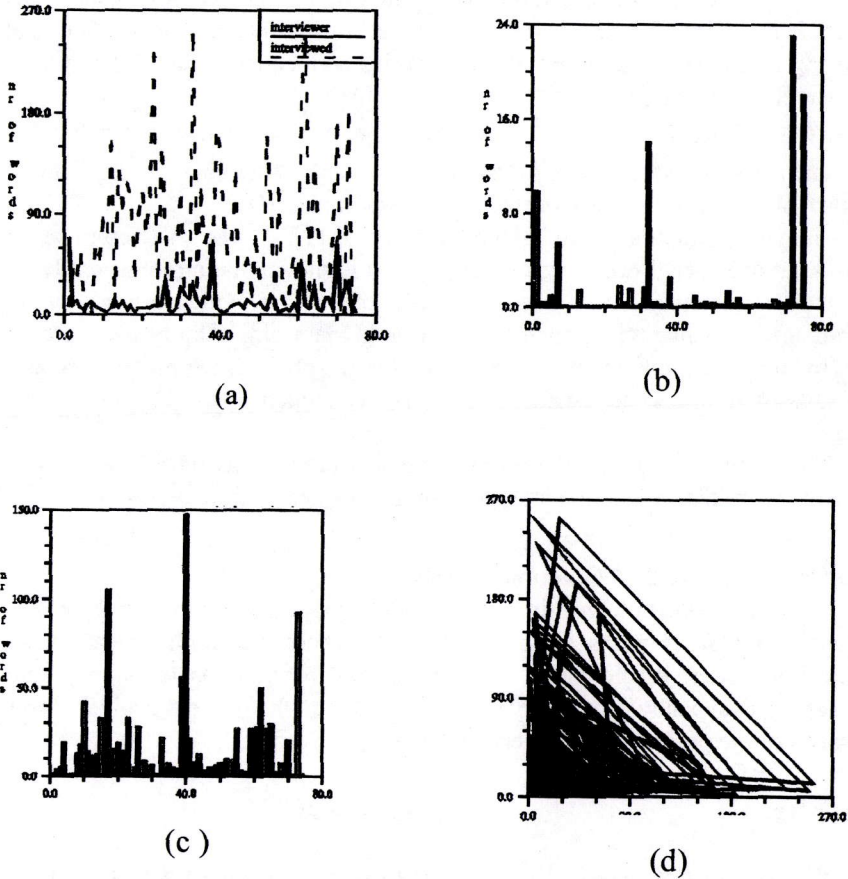


Fig. 1: Interview nr. 23 : (a) the number of words said by the interviewer (question) and the number of words uttered by the interviewee (answer); (b) the ratio between the number of words said by the interviewer (question) and the number of words said by the interviewee (answer) ; (c) ratio between the number of words said by the interviewee (answer) and the number of words uttered by the interviewer (following question) ; (d) the conversation attractor

These phase portrait plots are the most interesting: most conversation attractors showed a regular shape like in figure 1 (d) but the 30% of the conversation processes showed a different behaviour. A detailed analysis underlined that, in most anomalous

protocol, during the conversation conduction the interviewer was in trouble following the interviewee speech and fitting the process evolution.

Phase-portrait nr.6

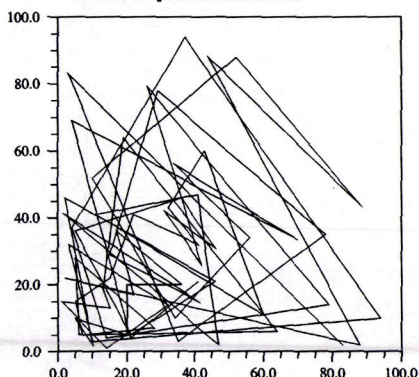


Fig. 2 Interview nr. 6 phase portrait

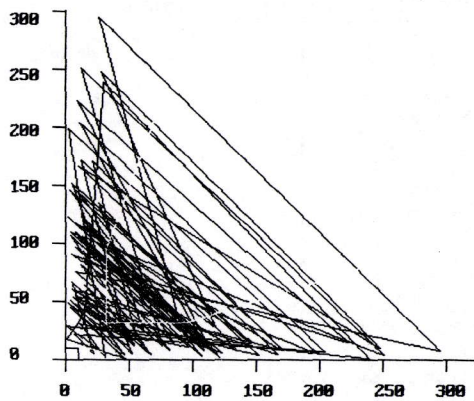
Often, in their notes the interviewer revealed he/she used a "layout" to conduct the conversation. Let us consider, as an example, the interview number 6. In the first part of the protocol, before the description of the conversation, the interviewer wrote:

"I was supposed to write a protocol on the motivational interview with a student of the first year of Psychology... I had many difficulties in finding answers... my worry was growing...I created a layout with possible questions I could ask himWith this concrete tool in my hand I hoped I could solve my heavy problem of the first contact with an unknown person...I am very shy. The consciousness of the layout was reassuring me"

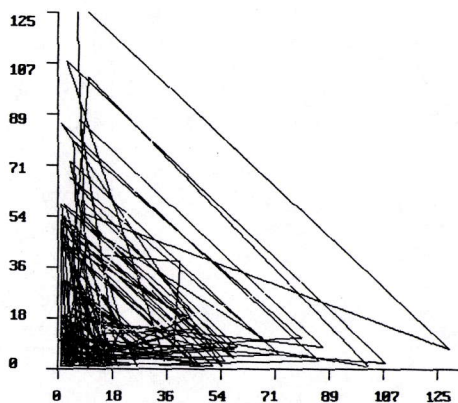
In figure 2 the phase portrait of this interview is shown. Statements taken out from the first part of the protocol transmit a strong anxiety about the experience of the interview. The interviewer seems to try to shirk the uncertainty of the future interaction through the usage of a concrete tool. This instrument, due to its concreteness, seems to stand for a refuge from the intangibility of the mind world, she searches outside the relation for what she fears that cannot be found inside. The rigid usage of a layout, alters the normal evolution of the dialog dynamic. The phase portrait shown in figure 2 evidences the unnaturalness of the relationship developed in this circumstance.

4.1 Evolution Parameters

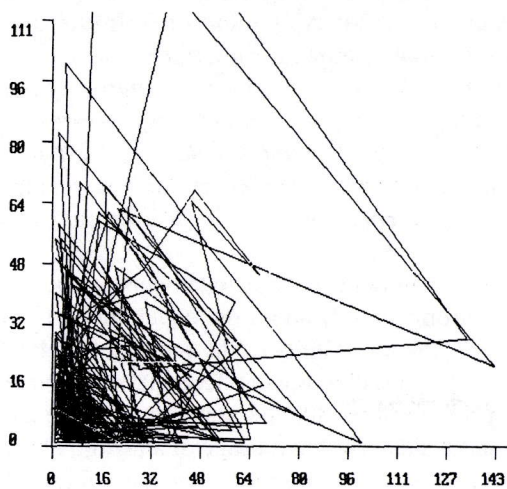
A careful observation of the phase portrait plots underlines that usually points are spread closed to axis, since, if the interview gave speaking space to the interviewee, his spoke was concise respect to the answer of the interviewee.



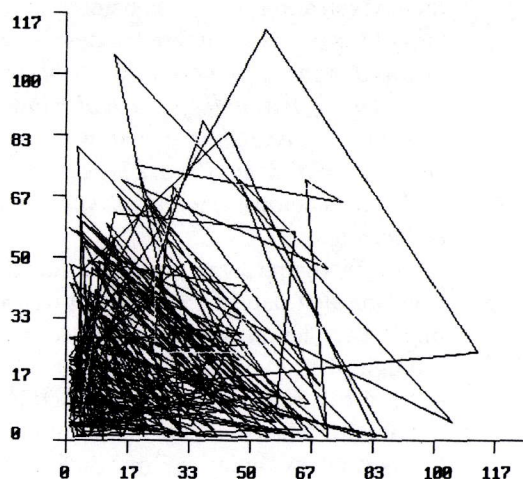
(a) Interview nr.643



(b) Interview nr.159



(c) Interview nr.166



(d) Interview nr.274

Fig. 3 Phase portraits of interview some interviews: they show different levels of disorder

Most interview showed a regular behaviour like that in figure 3 (a) and 3 (b). Singular points in figure 3 (c) and 3(d) are generated when both X and Y has a large value, that means that both interviewer and interviewee interacted with many words. These points indicates anomalies within the interview flux

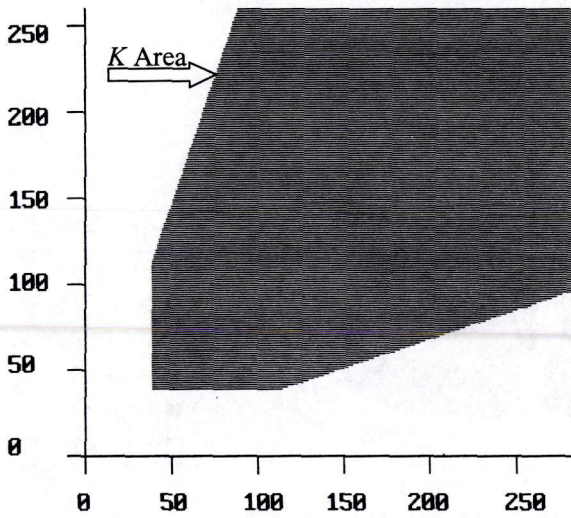


Fig.4 Mask for the computation of QP, and QM indeces

Let define the mask shown in figure 4 which determine an area K . Its limit shapes are defined as:

$$y = \begin{cases} a * m & a * m \leq x \leq b * m \\ \frac{b}{a}x + \left(\frac{a^2 - b^2}{a}\right) * m & x \geq b * m \end{cases}$$

and

$$x = \begin{cases} a * m & a * m \leq y \leq b * m \\ \frac{b}{a}y + \left(\frac{a^2 - b^2}{a}\right) * m & y \geq b * m \end{cases}$$

were m = media of words the interviewer said during the whole interview and $a=2; b=6$ are constants. This mask is adapted to the interview to preserve the interviewer speaking stile (concise or prolix) and it allows to underline only particularly long and elaborated intervents. We choose straight lines with rate

b/a because usually there is a direct correlation between the intervals of the two partners.

Interview distribution against QP

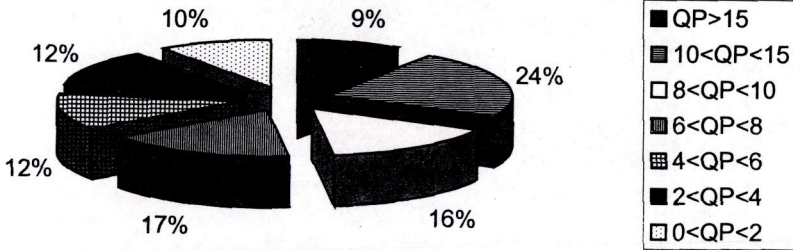


Fig. 5 Interview distribution against QP

Let then define QP index as: $QP = \frac{100}{ntot} \sum_{i \in K} i$, where $ntot$ is the total number

of interactions within the interview; and $QM = \sum_{i \in K} \frac{(y_i - a * m)}{a * m}$.

QP ranges from 0 to 29.4.

It gives information on the frequency percentage of the anomalous phenomenon:

$QP \in [0 - 3]$ indicate 'normal' interview; $QP \in [3 - 7]$ indicate some small rigidity;

$QP > 7$ indicate very rigid interviews.

QM ranges from 0 to 44.2.

QM gives information on the longness and the strongness of the interviewer interventions and it is helpful to weight in some way to weight QP values. Of course an interview with $QP=5$ and $QM=13$ is largely more problematic than an interview with $QP=5$ and $QM=2$.

Large values of QM and QP underline that during the interview many interactions between the partners, with many words each occurred: maybe the interview atmosphere was too charged with anxiety and nervousness or perhaps the interviewee didn't answer following the expectation of the interviewer. In both cases something

hardened“ the dialog flux: it looks like an attractor external to the relationship lead a rigid interview conduction.

Interview distribution against QM

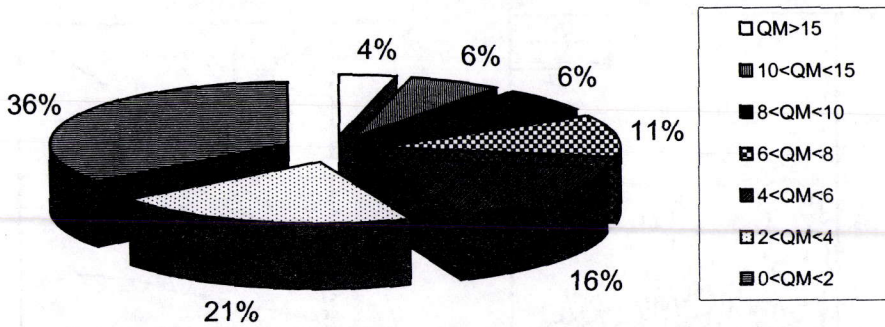


Fig. 6 Interview distribution against QM

Referring, as an example, to the interviews which phase portrait are plotted in figure 3, the corresponding QM and QP parameter values are (a) $QM=QP=0$, (b) $QM=3.85$, $QP=3.1$; (c) $QM=8.2$, $QP=9.9$ and (d) $QM=24.7$, $QP=14.2$

Most anomalous interviews described the usage of an external layout, but a detailed analysis on each protocol containing the word “layout” showed that the troubling element in the process was not the layout by it-self but its wrong usage. The evolution of the process was disturbed when the attention was shifted outside the interactive dynamic. The usage of a layout does not look to hamper the relationship evolution when its role was limited to a possible aid, when it wasn’t a rigid aim of the interview. When the layout was too important for the interviewer, it became a trouble in the communication. It became a screen behind which hiding himself (with the fallacious hope of masking emotions). It was like a sheet anchor to overcome moments permeates of void, of uncertainty, of anxiety. The usage of external tools to overcome these moments, without reflecting on them, deprives the conductor of a fundamental way of increasing the knowledge both about himself and about the interviewee. The layout become a script where packing the dialog, trying to force the relationship reality within his own mental schema. It seems to be an instrument difficult to be used, specially from beginners; its wrong usage compromises the conversation flow. The layout was created before the interview, off line to contain the interviewer needs to organise the information according to a logic sequence. Paradoxically, they risk to result in a lost of the information coming from the relationship. The relationship is

liveable only within the 'hic and nunc', if both partners are available to play a game in which, at each round, the move cannot be either foreseeable or foreseen.

4.2 Language evolution

Interview nr.47

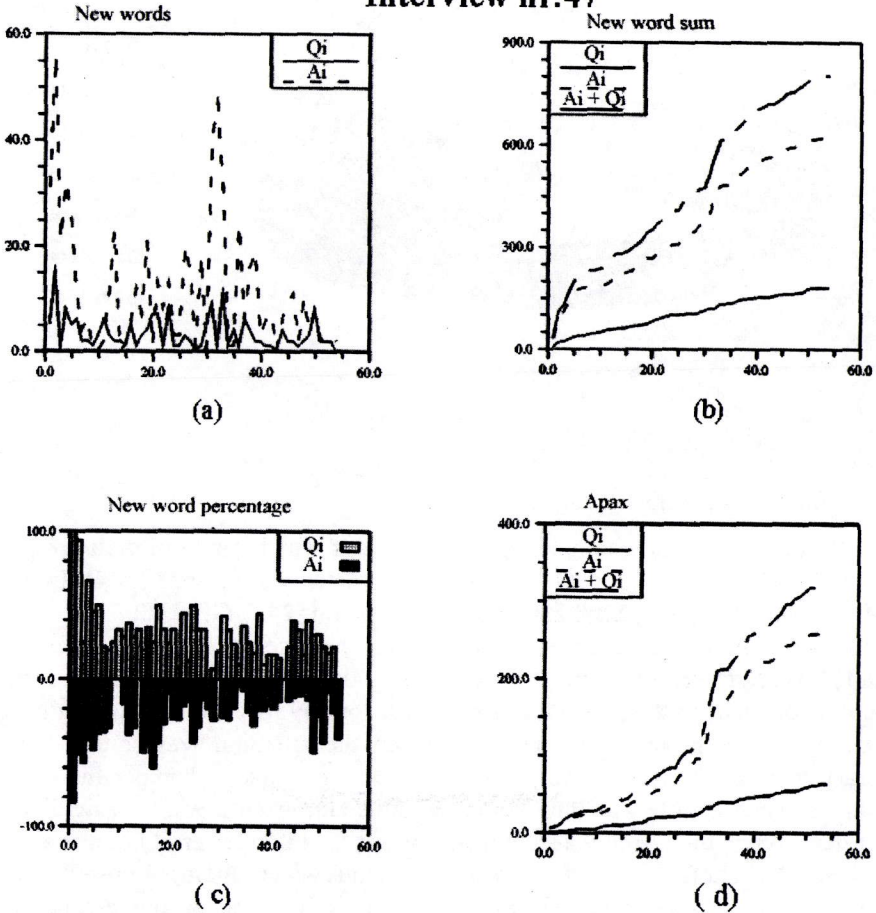


Fig. 7 Plot of the variable 'introduction of new words' in the interview nr. 47. (a) number of new words introduced by interviewer (continuous line) and interviewee (dot line); (b) sum of new words introduced by interviewer (continuous line), interviewee (dot line) and total (line-dot); (c) relative percentage of new words pronounced within each interaction (words from interviewee are plotted on the negative square); (d) apax number for interviewer (continuous line), interviewee (dot line) and total (line-dot).

During the conduction of a psychological interview the interviewer is supposed to adapt his language to the interviewed way of speaking.

To verify the observance of this law, we analysed the behaviour of the variables 'new word introduction' (word reused during the interview continuation) and 'apax' (word used only once during the interview) for interviewer, interviewed and for both of them.

If they build a common language the graphic behaviour of these variables should saturate and the amplitude of the shape characteristic of the interviewer should be lower than the shape of the interviewed. Unfortunately we could analyse these variables only through forms, not through lemmas, and this makes a lot of differences in Italian.

Nevertheless, as shown in figure 7 referred to the interview number 47, the whole data set shows a saturation trend. Probably the saturation phenomenon is grater than what these plots show. The first plot (figure 7a) shows the number of new words introduced by interviewer (continuous line) and by interviewee (dot line). It is easy to see that the interviewee introduces more new words. The second plot (figure 7b) underlines the saturation phenomenon plotting the sum of new words introduced by interviewer (continuous line), interviewee (dot line) and total (line- dot). At this point is good to notice that the interviewer curve saturate more quickly. The difference between the two roles is even greater in the apax plot (figure 7d). Finally plot (figure 7c) shows the relative percentage of new words pronounced within each interaction (words from interviewee are plotted on the negative y-axis in order to be more readable). From plots of figure 7 we can derive that the whole process interview is a global unity from the language point of view. Both saturation and limited number of introduced new words indicate the level of attention from the interviewer to hang over the semantic world of the interviewer.

5 Conclusion

Over 1000 motivational research interviews made from students during their university course have been analysed. Through word counting the conversation process phase-portrait has been estimated. This procedure allowed information extraction on the conversation evolution and allowed the detection of information on the conversation path. Plots with anomalous paths indicate situations where the communication has been troubled from external references (i.e. incorrect usage of layouts, necessity to arrange the information following pre-established logic sequences). In these cases the interviewer was prevented from following adequately the dynamic of the process: he/she lost a part of information coming from the relationship. This procedure can be used to analyse the evolution of any dialog especially when the reciprocal definition of the relationship involves the recognition of different roles (i.e. the therapeutic dyad, the teacher- pupil relationship etc.). Work is in progress to better evaluate the "language saturation" forms lemmas.

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