THE DYNAMICS OF SELF-ESTEEM

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ABSTRACT

The purpose was to specify advantages and limits of dynamical perspective proposed by Nowak and Vallacher (1998) for social psychology studies. This perspective contributes massively to new knowledge in economy, biology and motor control. Theoretical models, methods, self-assessment tools, and time series analyses are complete to verify hypotheses from nomothetical approach and to determine impact of daily events on self-perception. Some example will be given with self-esteem. This new scientific path needs attention to prevent fashion effect and critic disconnection. Epistemological weaknesses, such as analogies, conceptual bounds, technological illusions, or false time series analyses, are abundant. Sport psychologists, working on behaviors, emotions and thoughts interactions (such as self-esteem, self-efficacy, motivation, and anxiety) are in phase with this perspective. Nevertheless, they must avoid weakness underlined by this paper.

INTRODUCTION

The operational basis of social psychology aims to demonstrate linear relations between cause and consequence to explain reality. The postulate is that knowledge of simple structure and function can explain seeming complexity of thought, feeling and behavior in manifest or imaginary social situation (Allport, 1985). This analytic and reductionism approach was the only path to explore construct during the first century of social psychology. If this paradigm underlines relations between variables, some psychologist produced critics for the poor practical interest and heuristic limits (Kimiecik & Blissmer, 1998). Moreover, this reductionism allows researchers to neglect or underestimate time and ecological context influence to characterize studied variable. Thus, causal relationships derived from analytic methods stay limited to generalization of thought, feeling and behavior, to explain individual behavior in ecological context and to produce some prevision of behaviors.

According to the philosopher Thomas Kuhn, science does not evolve with simple accumulation of knowledge, but rather with change of manner to conceive and treat scientific problems. Recently, Nowak and Vallacher (1998) consider that complexity in psychology has its own reality and can not be reduced to several elements, even if they are cumulated. They proposed to develop a new approach named dynamical social psychology. This orientation includes recent works from physics and biology about complexity illustrated with the formula the whole is not the sum of parts, new properties emerge from the overview of system.

Self-esteem represents one's general or typical feelings of self-worth and self-liking (Greenier, Kernis, McNamara, Waschull, Berry, Herlocker & Abend, 1999). The term physical self, on the other hand, has a more specific meaning. It reflects the domain of perceptions of one's body, and the corresponding feelings of physical self-worth, with these perceptions particularly focused

on sub-domains such as physical condition, sport competence, physical strength, and attractive body (Fox & Corbin, 1989; Sonstroem, Speliotis, & Fava, 1992; Sonstroem, Harlow, & Josephs, 1994).

Classic works in social psychology using questionnaires with Likert-type response scales and a few reports presenting longitudinal data have shown that the mean group level of self-esteem does not significantly differ over time in adults, suggesting good stability across situations (Burke, Kraut, & Dworkin, 1984; Demo, 1992; McCrae & Costa, 1994). This stability may reflect self-consistency with the development of feelings of unity, independence, predictability, and control (Epstein, 1979). The notions of self-schemata (Markus, 1977) and the primary basis of security (Rogers, 1959) were advanced as explanations of this stability such that, if an individual were to experience no critical life events, and if measurement error could be eliminated by directly assessing the content of the person's mind, self-esteem would be characterized as a single point on an appropriately labeled scale.

Nevertheless, dynamical psychology considered declarative perception of the self as a highly complex process (Nowak, Vallacher, Tesser & Borkowski, 2000; Vallacher, Nowak, Froehlich & Rockloff, 2002). Self-esteem can be considered as phenomena emerging from the interplay of the many elements included in a system. The mind cannot be reduced to separate mechanisms, but instead mutual influences and coordination must be taken into account. Specific brain structures carry out cognitive and emotional functions in parallel but also interact to produce higher order structures with emergent properties. Thus, the functioning of self-esteem could be more complex than proposed by classical studies. The purpose of this chapter was to examine how self-esteem functions overtime at an intra-individual level using a brief questionnaire, daily assessment and time series analyses. The first part focuses on theoretical and methodological exigencies. The second part shows some recent works about instability and dynamics of self-esteem.

THE DYNAMICAL STUDY OF SELF-ESTEEM

Theoretical aspects

Limits of classic approaches in social psychology

The study of psychological constructs used predominantly static nomothetic method, in other words based on few repeated measures spaced at least one month. The results showed inter-individual differences and correlates without never determine causal functioning or predict change of studied dimensions for a subject (Kimiecik & Blissmer, 1998; Nowak & Vallacher, 1998). This lack to answer to both main aims of social psychology needs a new approach in which intra-individual variability will play a crucial role. The priority attributed to personality according to the structuralist and dispositional perspective (Coopersmith, 1967; Lord, 1997; Rosenberg, 1979), in consequence to the determination of auto-evaluative and behavior permanence could have neglected intra-individual variability, attributed spontaneously to measure error (Marsh & Yeung, 1998).

Studies in social psychology have also excluded understanding of ecological context to characterize measured scores. Some procedures such as artificial task, break of situation during completion and retrospective techniques have isolated variables without contextualization. With disconnection to ecological evolution of studied dimensions, social psychology produced intangible models, sometimes simplistic, incompatible for practice (Kimiecik & Blissmer, 1998; Lawson, 1990; Newell, 1990).

Nomothetic works focused on linear relations in multidimensional or hierarchical structure of self, in other word on direct and proportional links. Nevertheless, the effects in most biological systems are not proportional to values of causes, for example heartbeats (Goldberger, 1999).

Multidimensional or hierarchical model validated by unique measure (except to control reproducibility for questionnaire's validation where a second assessment is generally conducted

after one month) are inspired to a thermodynamic rule and a biological principle neglecting time. The rule of energy conservation (invariance and symmetry overtime) and the principle of homeostasis (stationary dynamics, the system tend to reduce variability and to maintain constancy of internal functions) ignores time because of the return to basal level and seems to be obvious (Prigogine, 1994). Whatever time delay, the return seems to be ineluctable. In consequence, the change of psychological dimension's score was considered at worst as measure error (Marsh & Yeung, 1998) or at best as temporary perturbation (Kernis, Grannemann & Barclay, 1989). This functioning supposes a reference value. This basal level is determined during an "at rest" assessment session with a questionnaire. Prigogine (1994) contests elimination of time in classical rules of physics. Studying dissipative structures, he showed that until the system dissipates energy and stay in contact with outside environment, the pattern of behavior is non-equilibrium (Prigogine, 1994). It is the contrast with equilibrium structures such as crystals. Once created, they stay isolated and are inert structures without dissipation of energy (Prigogine, 1994). More the level of complexity increases (chemistry, life, brain), more evident is the effect of time. Thus, the non-equilibrium creates long term correlations. Without theses correlations, we can not have life, or thoughts. The equilibrium becomes a particular state of a more fundamental rule of non-equilibrium (Prigogine, 1994). Moreover, the third thermodynamic rule explains that entropy of a system increases overtime. In that case, the disorder of the system increases overtime. A feeling becomes more and more complex overtime. In consequence, time can not be excluded in social psychology.

The needs of dynamical approach in social psychology

Nowak and Vallacher (1998) propose to open social psychology to ecological context, time and complexity. This new area is inspired by several paradigms such as incertitude principles starting with Heisenberg, probabilistic causality starting with Broglie, relativity starting with Einstein, chaos starting with Poincaré and emergency starting with Lewes.

According to Nowak and Vallacher (1998), certain psychological variables can be considered in an ecological context, as the consequence of complex systems submitted to incontrollable and unpredictable impacts. Each value emerges from auto-organization process at t time. Thus, studying separately components of the system can not determine the global functioning. The mind can not be reduced to separate mechanisms without understanding mutual influences and coordination. In consequence, several specific psychological functions operate in parallel to create superior structure susceptible to obtain emergence of a product understandable by all (Varela, Thompson & Rosch, 1993).

The aim of this perspective is to propose a description (1), a characterization (2) and a modelization (3) of behavior of complex system. The description's phase (1) depicts ecological changes of psychological variables in examining « natural » functioning of a subject overtime and in indicating frequency and nature of perturbations and also variables probably implicated to these changes. Then, the researcher extracts regularity, cycle and change of thoughts, emotions and behaviors. The characterization's phase (2) produces an(several) impact(s) (constraint or perturbation) directly on system and qualify/quantify the effects on mean, instability and dynamics of studied variables. The modelization's phase (3) creates pattern of explanation in the one hand using psychology's knowledge and in the other hand using mathematical equation. The model specifies the dynamics overtime in articulate combination constituted by several elements and parameters influencing its different states. Compared to static system, a dynamical system integrates influence of preceding time (y_{t-n}) among parameters characterizing current state (y_t).

A substantial difference with dispositional theories (based on the *true* and *immovable* value of trait) is that dynamical theories include ε_t term in the model. This term does not reflect the distance between true value and observed value indicating measure error. It reflects random and continuous change, favorable or unfavorable (Kenny & Campbell, 1989). In ecological condition, the system evolves continuously overtime. Instead it is the place of minor events more than

catastrophes, the chain reactions of all amplitude belong to its dynamics. A same event produces minor consequence or catastrophe. In biology, theses systems rarely attain *steady state*, they function from a metastable state to another (Bak & Chen, 1991).

The advantage of dynamical social psychology is that the researcher examines the trace of psychological variable transcribed in a natural and authentic context. She or he requests to subject to answer frequently and spontaneously, eliminating retrospective biases related to memory. This trace noted *in situ* is related to its context in order to improve sense. In consequence, a minor event can become as well important as major event. If psychologists massively focused on impacts of major events, they often under-estimate consequences of minor life, frequent and low intensity events. First, they considered that participants are not attentive to minor events, thus with weak memorization. Second, participants create adaptive routines to minimize minor events (Hays, 1989). Classifications of life events (positives and negatives) were established excluding in the one hand distinct feelings between subjects and, in the other hand, importance attributed to each event in function of context. Cognitive interpretation and emotional state play major role in the psychological weight assigned to life events. Dynamical social psychology attempts to extract information close to event and his feeling. The prevalence of a particular process, it periodicity, it covariance can emerge within it context, named ecological validity (Brewer, 2000).

Marsh and Yeung (1998) underlined the limits of nomothetic studies to verify application of psychological process with an individual. For example, the undetermined debate between *dispositional* (defender of personality trait), *situationist* (defender of state) or *interactionist* (defender of dynamical equilibrium or homeostasis) theories is tangible proof (Baumeister, 1993; Brown, 1998; Strelau, 2001). The new path of social psychology initiated by Nowak and Vallacher (1998) notifies interest to explore with an intra-individual manner hypotheses let in abeyance by inter-individuals studies.

Limits of nomothetic approach to characterize self-esteem

Self-esteem self can function as *trait*, *state*, or *dynamic equilibrium*. A *trait* is stable over time and across situations, whereas in the case of a *state*, circumstances can raise or lower the evaluation of perceived dimensions. The *dynamic equilibrium* model can be a combination between trait and state.

If self-esteem functions as a *trait* (Burke, Kraut & Dworkin, 1984; Coopersmith, 1967; Epstein, 1979; McCrae & Costa, 1994), the inferred model is based on the thermodynamic principle of energy conservation and the homeostatic principle. For example, if a positive or negative event influences self-esteem, then these models emphasize self-conservation, the progressive return to a basal level with weak oscillations (linked exclusively to random variability due to measurement error). Abundant empirical evidence indicates that global self-esteem is resistant to change. According to dispositional theories, a trait is considered to be a relatively stable and individual-specific generalized tendency to behave in a certain way (Strelau, 2001). The literature shows the stability of global self-esteem especially in adults (McCrae & Costa, 1994). In consequence, the correlational literature is replete with evidence of associations between self-esteem level and systematic behaviors or psychological reactions. For example, people with low self-esteem often report depressive episodes (Butler, Hokason & Flynn, 1994). They report more negative emotions and are more sensitive to negative events (Dutton & Brown, 1997; Epstein, 1992). They are more concerned by and with social evaluations (Baumgardner, 1990). Conversely, individuals scoring high in global self-esteem often present a socially conformist image of themselves (Francis, 1997). They are generally characterized by higher levels of sociability, impulsivity, and emotional stability (Francis, 1997).

If self-esteem functions as a *state* (Butler *et al.*, 1994; Leary, 1990), then the perceived dimensions could be considered as short-term histories changing randomly in response to life

events. According to situational theories (Leary, Tambor, Terdal & Downs, 1995), changes reflect dependence on endogenous and exogenous variations. Recent research has emphasized the variability of self (Greenier *et al.*, 1999; Kernis, 1993; Nezlek, 2002; Nezlek & Plezko, 2001; Nowak & Vallacher, 1998; Nowak *et al.*, 2000) and subjective well-being (Headey & Wearing, 1989). State self-esteem appears to function as a subjective marker that reflects the individual's social standing in a particular setting (Leary *et al.*, 1995). People with unstable self-esteem, whether low or high, show more extreme emotional and behavioral reactions to events involving other threats to self-esteem. For example, the variability of perceived dimensions reveals central information about depression (Greenier *et al.*, 1999), quality of life changes (Barge-Schaapveld, Nicolson, Berkhof & de Vries, 1999) and behavior (Kernis *et al.*, 1989). Individuals with unstable self-esteem more often experience anger and hostility (Kernis, Grannemann & Mathis, 1991). Stability of self-esteem moderates the relation between level of self-esteem and depression (Kernis *et al.*, 1991).

If self-esteem functions as a *dynamic equilibrium*, then several oscillations around a reference point, though it denotes a tendency to return to a fixed-point attractor on a longer time scale can be observed (Headey & Wearing, 1989; Nowak *et al.*, 2000). Over time, the dynamics of this system tend to cohere into reliable patterns, referred to as attractors. In this particular case, the subject maintains a relatively stable and positive self-evaluation despite a high number of negative elements in his or her self-system (Nowak *et al.*, 2000). She or he concentrates on the positive regions and disregards the negative regions (Pelham & Swann, 1989; Showers, Abramson & Hogan, 1998). Compared to fixed trait, the time needed to return to the reference value can be much longer, and the magnitude of oscillations can be higher. The system may react to endogenous or exogenous influences. The influences tend to be short-lived, however, so that the system quickly returns to its attractor. Occasionally, the reference value will change because of an event judged to be important by the person. At that point, the self-system is pushed to a new equilibrium level, making it difficult to return to its initial state (Nowak *et al.*, 2000)

Dynamical social psychology presents an innovating way to determine psychological processes that regulate evolution of self-esteem (Ninot, Fortes & Delignières, 2001; Nowak *et al.*, 2000). Self-esteem is conceived as an emergent product of multiples interactions in biological and psychological system of one human being. This auto-evaluative dimension can be considered as an order parameter traducing a current state of a system submitted to endogenous constraints (biopsychological) and environmental impacts (physic and social). Moreover, dynamical social psychology offers also perspectives to determine causalities in hierarchical model including self-esteem (Fortes, Ninot, Leymarie & Delignières, 2004) and estimations in short term for a subject (Ninot, Fortes & Delignières, 2005). From psychopathological viewpoint, it can describe process of identity construction and associated troubles (Marks-Tarlow, 1999). Methodologically, this approach needs repeated, frequent and regular measures at human scale to verify all of these functioning hypotheses.

Methodological aspects

Limits of classical approaches

If review of question and meta-analyses emphasize the need of longitudinal studies in social psychology, researchers remain often perplexes to use this kind of protocol design. They wonder if logistic efforts to control parasites variables worth while. The cost of such protocols (subjects, researchers and material) burdens massively the laboratory's resources. Students, concerned to university diploma generally less than three or four years, prefer avoid this kind of protocol. The experimental mortality is important (but rarely specified in psychological publications) for several reasons, sometimes unthinking. This leave affects generalization of results. If longitudinal protocol design theoretically requires need assessment at the same time for each subject, material and organizational constraints will prohibit. In brief, psychologists wonder if parasite factors can not the

principal cause of observed significant change. Then, their choice are directed to soft longitudinal (minimizing number of measures or reducing inclusion criterions) and/or *cross-sectional* protocols. Unfortunately, it is at this moment that the micro-variations susceptible to provoke periodic change are lost. The low frequency of acquisition will hide studied process.

In transversal experimental design using questionnaire, strategies for equating groups are neither perfect. Two identical individuals can not be found, including homozygote twins. Therefore, constitution of control group is impossible, as well as determination of median behavior of a group will not reflect an individual behavior (Hanin & Syrjä, 1995).

The selection of persons with specific inclusion criterions often imposes artificial assimilations. Errors of sampling are then possible and can indirectly facilitate hoped result (Bouvard & Cottraux, 1996).

The relevance of general population is required to obtain powerful generalization. In several cases, it is not possible to include enough persons because of several problems (incompatibility of groups, faraway residence of subjects, direct costs…).

The participants may have favorable or unfavorable presumption related to experimental design proposed in function of preliminary information or past experiences. They will have diverse motivations and behaviors. For example, it is well demonstrated that prestige of university or scientific authority influences results of study (Bouvard & Cottraux, 1996). With weak sampling, this constraint generates insoluble biases.

The use of battery of classical questionnaires in longitudinal studies involves fastidious assessment session. The repetition reduces motivation. Participants risk to be bored and to complete improperly.

Attitudes, beliefs and personal convictions of researchers can also influence results within infrequent repeated measures. Double blind protocol is an appropriate methodological opportunity but occasionally take up in social psychology.

An experimented solution, rarely reliable, is retrospective method. Cognitive biases related to memory product several errors in information collection. More time period is prominent, more the studied event looks like to other life events, more that is make sense seems to implicit theory of participant and/or more emotion modifies thought, and more chances to obtain false information are majored.

The needs of dynamical approach in social psychology

The dynamical perspective requires idiographic protocol (Runyan, 1983) where data are assessed frequently over a determined period. An idiographic protocol design can be empirical (ecological context) or experimental (laboratory situation controlling variables or simulation).

In ecological situation, the method is named *everyday experience method* (Reis & Gable, 2000). Time unit is chosen in reason of discrete rupture provoked by sleep within biological and psychological rhythms (Williams, Suls, Alliger, Learner & Wan, 1991).

Three types of recording are proposed, (1) programmed, (2) random or (3) conditioned. The first one respects identical, uniform and determined interval of time (Mischel & Shoda, 1998). Interval must have sense theoretically and logically to describe behaviors and/or events appeared since last completion session. The aim of researcher is to optimize acquisition's frequency. A double acquisition's frequency related to studied mechanism is optimal. It avoids measure surcharges due to distraction, pseudo-knowledge without reading question or familiarities with the questionnaire. It improves manifest measurement of variable's change (Mischel & Shoda, 1998). This type of recording facilitates adherence to program research, determination of regularities and opportunity to apply time series analyses. The second type of recording, named *experience*

sampling method (ESM) developed by Csikszentmihalyi and Larson (1987), concerns a responses series with random apparitions of signal (fixed interval can be included). This kind of protocol avoids anticipation of response and permits to verify the state of participant during her or his activities. The third type depends of decision of the participant in function of life events defined preliminarily. If interval has sense, the risk remains difficulty to define exactly "events" and detect without ambiguity.

Whatever the type of recording, it is necessary that period and acquisition's frequency reflect an enough number of representative measures. Moreover, except specific study, apparition of major event needs an independent treatment.

Psychometric aspects

Limits of classical approaches

Even if researchers hope to obtain individual time series enough longer, it is impossible to ask to the participant to answer day-to-day to classical questionnaires including near thirty items, still more to a battery. The completion should be too prolonged and fastidious. The number of items systematically superior to four items by scale excludes measurements with restricted interval of time, in consequence, understanding of micro-variations.

The internal validity of a questionnaire used with a specific population is rarely tested and presented in publications. Authors trust validation session, even if they had occasion to check internal validity. It is often that a questionnaire validated with a representative sampling of general population is not structured in a part of this population.

The response's modality of most questionnaires measuring psychological constructs are weakly sensible. The Self-Esteem Inventory of Coopersmith (1967) uses a binary nominal scale. The Physical Self-Perception Profile (PSPP) of Fox and Corbin (1989) and Self-Perception Profile of Harter (1999) propose an ordinal scale with forced choice by tetrad. The French version of PSPP, Physical Self-Inventory (PSI), integrates an ordinal scale with a Likert at six modalities (Ninot, Delignières & Fortes, 2000). The both first modalities are weakly nuanced (figure 1). A sensible participant can have difficulties to determine herself or himself between two criterions, depending to situations.

Psychometric procedures of questionnaire's validation diverge between authors (Bouvard & Cottraux, 1996; Marsh, 1993). Nevertheless, authors consider five main criterions: content validity, internal consistency, external validity, predictive validity, and stability (retest). The third ones are well applied in social psychology (Reis & Judd, 2000).

The predictive validity permits to pronounce a prognostic with results. This procedure is classic in medicine, and very rare in social psychology. The lack of clinical verification limits routinely use of these questionnaires in individuals and can support certain presumptuous postulate apparently supported by retest procedure.

The retest (or stability coefficient) is a sine qua non condition for psychometric validation of a self-evaluative instrument. The retest relates an identical result between two measures realized in same conditions. The time interval is not fixed. Literature suggests periods from one week to two months. This test is massively criticized. It does not distinguish variability dues to possible change and measurement errors. Marsh (1993) and Schutz (1998) propose a new method based on mean stability corresponding to statistical difference of level score between both measures (with ANOVA for repeated measures and correlation coefficient between times), differential stability corresponding to individuals difference stability overtime with inter-measures correlation coefficient (capacity to an individual to maintain her or his position in the group), and structural stability corresponding to the degree of maintenance of latent variables. The authors justify the use of this last analysis within the postulate that psychological variables are personality's trait, in other

word, consistent whatever events and situations. However, the first two parts of this chapter underline that nothing prose that personality dimensions function like that, quite the opposite.

		Seems to me	Does not seem to me
1. In general, I do not worry	………………	☐	☐

Self-Esteem Inventory (Coopersmith, 1967)

Seems to me				**Does not seem to me**	
really	*a little*			*a little*	*really*
12. ☐	☐	Certain are happy with *BUT* themselves	other are rarely happy with themselves	☐	☐

Physical Self-Perception Profile (Harter, 1999) and Physical Self-Perception Profile (Fox and Corbin, 1989)

	Seems to me...					
	Not at all	A very little	A little	Enough	A lot	Absolutely
1. I have a good opinion of my self --	--1--	---2---	--3--	---4---	--5--	----6---

Physical Self-Inventory adapted from PSPP of Fox and Corbin (1989)

Figure 1: Responses modalities of questionnaires measuring self-esteem

The needs of dynamical approach in social psychology

Obtaining time series enough extended is not easy in social psychology. The completion with classical instruments quickly becomes fastidious. Participants declare to have not enough time to assess twice a day using a paper-pencil questionnaire. If they are constrained, they complete automatically in memory of last answer (learning effect), selectively claiming boredom or fatigue, falsely (playing a role), or randomly (to reduce assessment time). These behaviors contribute to invalidate protocols.

Alternatives to these biases are open question (informative on a descriptive plan but with risk of spontaneous comment related to event and not related to studied phenomenon), check-list (quick use for unpredictable event, but limited in other cases) or brief questionnaire including one item per studied dimension (Reis & Gable, 2000).

The brief questionnaire supposes that the lack of internal consistency due to weak number of questions is compensated by repetition of completion. A single item by dimension removes redundancies. It decreases fatigue, frustration and boredom (Robins, Hendin & Trzesniewski, 2001). Spontaneity and promptness to complete eliminates memory biases. Moreover, daily assessment reinforces curiosity of the participant to know her or his data and, in consequence, motivates more than rare occasions.

Ordinal scale constituted by a list of three to six terms organized in intensifying order offers a limited number of responses, thus slight nuance (Jensen, Karoly & Braver, 1986). These scales are

weakly sensible and do not detect low variation of intensity. In pain assessment, the signification of term does not necessarily reflect the same intensity between patients. Moreover, variation of pain experience intensity is not identical between scale's terms (Ohnhaus & Adler, 1975). Interval between the selected word and the next or preceding does not represent the same unit. For example, an intensive pain that becomes moderate is not comparable to a weak pain becoming nothing.

To avoid learning effects and response memorization and to increase sensibility of scale, visual analogue scale (VAS) appears to be the best solution (Huskisson, 1974). This scale is easy to administrate and to complete. Severity of pain is perceived only by the subject in trouble with. It is a personal psychological experience to which observer does not play any legitimate role to appreciate accurately. It is now admit that pain is a subjective phenomenon. The patient is the only one judge to determine pain overtime. The complexity of pain phenomenon cannot resume to an only one assessment session. VAS has advantage to be sensible and adapted to repeated measures (Huskisson, 1974).

VAS is a single 10-cm horizontal line without formal indications. For example in social psychology (figure 2), participants are requested to draw a vertical trait on the line anchored by "not at all" (measured 0.0 cm) at the left extremity and "absolutely" at the right (measured 10.0 cm). The researcher then determines the trait's distance from the left extremity and converted the response to a score ranging from 0.0 to 10.0.

Globally, you have a good opinion of yourself

Not at all _____ Absolutely

Figure 2: VAS

VAS is a self-evaluative method largely used, diffused and short to assess chronic and acute pain (Jensen *et al.*, 1986). The scale is reliable and reproducible with pain (Huskisson, 1974; Price, McGrath, Rafii & Buckingham, 1983). It reproducibility is better with 10, 15 or 20 cm than 5 cm. The results about pain are not influenced by age, sex or disease. The pain's scores measured with VAS in patients are similar than those completed by clinicians and nurses (Banos, Bosch, Camellas, Bassols & Bigorraa, 1989).

Inconvenient of VAS concerns it misunderstanding score that is 11% for the pain in a general population (Paice & Cohen, 1997) and only 2,7 to 4% for simple verbal scale (Jensen *et al.*, 1986). It use is forbidden in elderly persons (more than 90 years old), young children (before 6 years old) or patients presenting cognitive troubles, spatiotemporal disorientation or linguistic difficulties. Cognitive limits decrease understanding of nuance and self-judgment permitting to traduce personal experience to geometric presentation (Carlson, 1983).

Brief instrument to obtain self-esteem time series

Recent studies validated brief questionnaires measuring one psychological dimension with single item for self-esteem (Robins *et al.*, 2001; Ninot *et al.*, 2001). These instruments using VAS have good balance between practical need and psychometric criterions (Robins *et al.*, 2001). Nevertheless, these tools are not valuable for all psychological dimensions. For example, a multifaceted concept is unconceivable to explore with this kind of tools.

The PSI-6 items, validated in French (Ninot *et al.*, 2001), assesses global self-esteem and physical self components (Fox & Corbin, 1989), physical self-worth, physical condition, sport competence, physical strength, and attractive body (table 1). The questionnaire is completed on

single paper, on personal pad or on personal computer using dedicated software. The six items are presented in random order to reduce the likelihood of systematic responses.

For the software version, participants have to move the cursor along a line anchored by "not at all" at the left extremity and "absolutely" at the right (figure 2). The cursor is placed on the left before answer. The software then determines the cursor's distance from the left extremity and converted the response to a score ranging from 0.0 to 10.0.

Participants are also asked to move the cursor to the center of a 10-cm horizontal VAS. This additive item is designated to estimate the measurement error and/or misuse (cognitive troubles, vision problems or fallacious responses) corresponding to the difference between the true value (5 cm, center of the 10-cm line) and the response mark.

Participants were not informed of these numerical scores and were not allowed to consult their previous responses. Last, a commentary zone is created after the VAS completion to offer opportunities to note events and/or everything in relation with the current psychological state (see an example in figure 8).

Dimension	Item
Global self-esteem	Globally, you have a good opinion of yourself
Physical self-worth	Physically, you are proud of who you are and what you can do
Physical condition	You would be good in an endurance test
Sport competence	You manage well in all sports
Attractive body	You think that you have a pleasant body to look at
Physical strength	When you come to situations requiring strength, you are among the first to step forward

Table 1: Items of Physical Self Inventory – 6 items

Time series analyses

Limits of classical approaches

Classical analyses devoted to repeated measures (t of Student, ANOVA) present several constraints that are sources of interpretation's errors.

To discriminate significant effects on dependent variables, these analyses require important sampling size, sometimes impossible to constitute. In some cases, a non significant result within 15 subjects can become significant with 40. The computation of effect size gives descriptive information but does not solve the problem. Moreover, these analyses can miss significant results because of variance's heterogeneity. Few subjects of the studied population submitted to an inverse effect can provoke a non significance. The exclusion of two or three subjects can be enough to obtain significant result but also to obliterate ethics of researcher.

These analyses can show significant time effect without clinical perception of subjects. This kind of results needs the development of clinical threshold, from which it is a real impact on life.

In experimental design, a person can answer with very weak score at four of five items for the same dimension. The last item can have a medium score. Even if the participant attributes more importance to the last item, the mean or cumulated score will mask the last response and alter ANOVA (Kimiecik & Blissmer, 1998).

To an intra-individual level, analyses of variances reveal anything on time stability of a series of repeated measures (Marsh, 1993; Schutz, 1998).

Often, researchers use ANOVA to examine a series of consecutive observations. Nevertheless, a postulate of ANOVA is that the residuals of measures are not correlated. It is not the case if the score at t time is linked to the previous score at t-1 time, in other word if data are auto-correlated.

The post-hoc tests present a different sensibility. For example, the Newman-Keuls test discriminates more than the Scheffé test. Here again, the researcher's ethics is overstress in case of doubtable result.

Last, an analysis of variance for repeated measures traduces a mean change of a group. The discussion is then about the change of a mean subject who stay absolutely artificial.

In consequence, new analyses are necessary, not well known in social psychology, time series analyses (Shumway & Stoffer, 2000).

The needs of dynamical approach in social psychology

The *mean level* of time series (mean of consecutive observations) takes sense if the period is enough longer and in case of stationary process. The first condition requires same intervals between measures over the studied period. To our experience, the minimum unit is 14 for bi-daily measures to obtain acceptable value of self-esteem, in other words a week. The second condition is more complex. A stationary process suggests that any trend can be discovered on the time series. However, a decrease or an increase can appear in a time series because of clinical change (see figure 1). Then, computation of *mean level* reveals few indications for the studied subject, and limits some conclusions of nomothetic studies about the significance of a single level score.

The *standard-deviation* is an instability indicator of time series used by several authors in social psychology (see 1.1.3.). It application to time series is restricted. This indicator derives from Gaussian statistic's hypothesis based on normal and random distribution of data around mean. Then, data are supposed non-correlated overtime. However, most of psychological time series present significant autocorrelations (Gilden, 2001; Slifkin & Newell, 1998), excluding the meaning of Gaussian's hypothesis.

We can propose other indicators of psychological instability overtime, such as *range* (difference between minor and major values over the studied period) and *mean absolute difference* (mean of absolute differences between two consecutive observations, in other word, the series is differenced, transformed in absolute values, and the mean of this new series is calculated).

Nevertheless, these descriptive indicators reveal a poor image of psychological functioning, because its ignore order in which data were collected. Time series analyses overlook these limits in producing information about dynamics, in other words, about the manner of variability is built observation after observation. Time series analyses aim to determine individual functioning (Slifkin & Newell, 1998).

A common analysis consists to compute *autocorrelation function* (ACF) of the series. The ACF is a Bravais-Pearson correlation coefficient from time series correlated with itself. This correlation is computed creating progressive lags. For lag 1, ACF is computed with pairs $(y_t; y_{t+1})$. The ACF describes the historicity of time series (Shumway & Stoffer, 2000).

In certain case, ACF reveals no significant coefficients. This indicates that no relation can be found between successive observations. This result is typical of white noise process, random succession of observations, and thus completely unpredictable. If mean, standard deviation and superior order moments are unchangeable and accompanying non significant ACF, then the studied

time series is stationary. An example of classic stationary process is state equilibrium or *steady state* (homeostasis). The variable randomly oscillates around stable reference value overtime (figure 3).
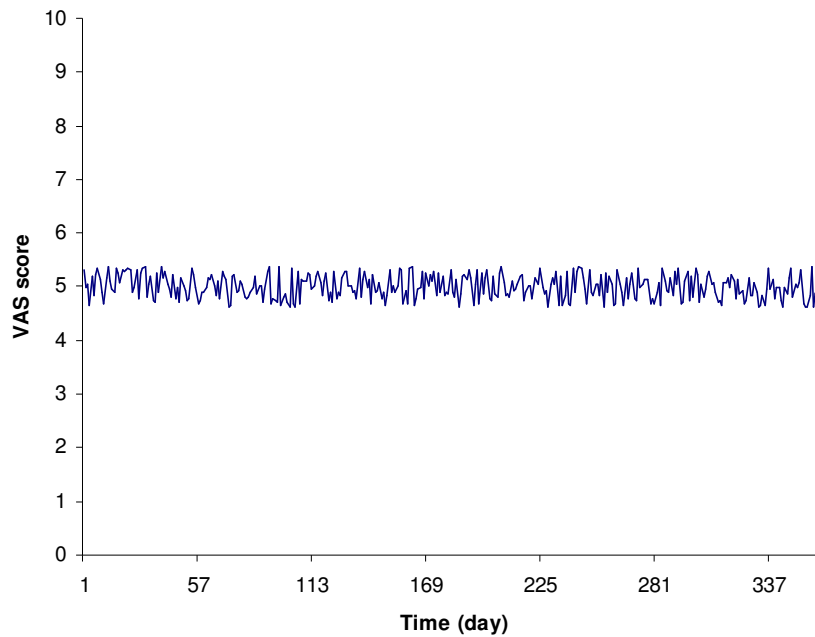

Figure 3: Simulation of stationary time series

This result remains nevertheless quite exceptional in psychology and biology devoted to ecological context. Habitually, researchers observe significant autocorrelations, which tend to decrease gradually little by little that lag increases. In other words, the observation at *t* time is particularly dependent to preceding observation *t*-1, un little bit less at observation *t*-2, etc. Time series analyses aim to forecast nature of this relation. The non stationary time series present to the opposite more or less important changes overtime (figure 4).
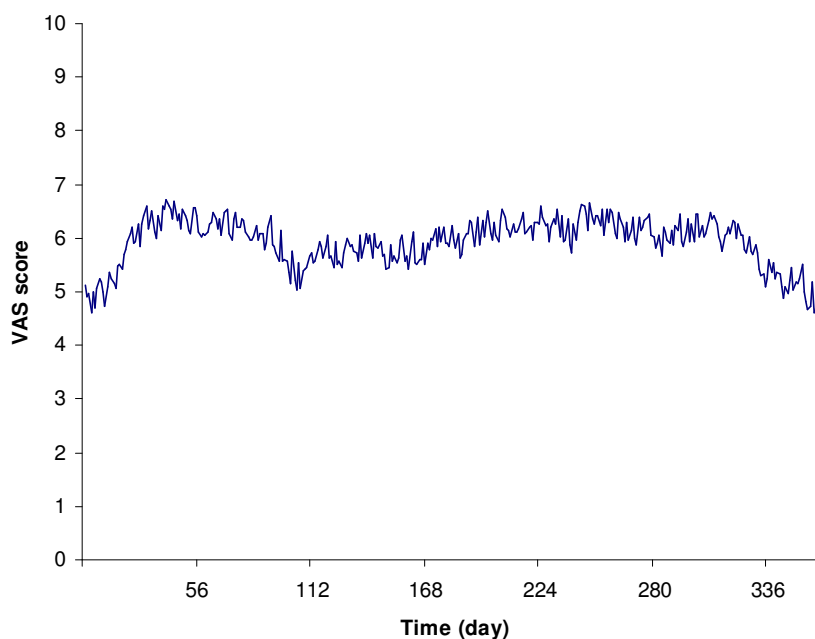

Figure 4: Simulation of non stationary time series

For a non stationary series, ACF must be significant from the first lag to high number of lags. The figure 5 shows ACF graph with significant lags from 1 to 28 (data from time series show in figure 4). A stationary series do not present significant lags or very rarely.

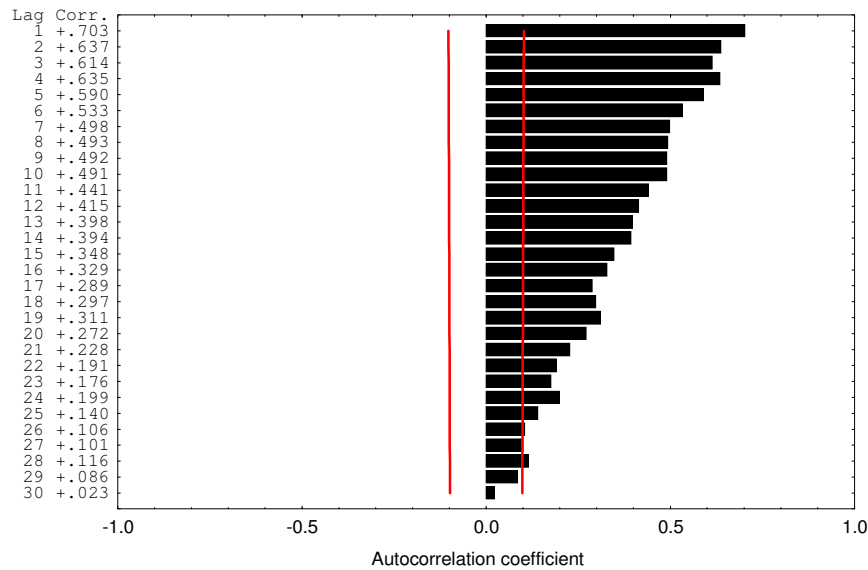| Lag	Corr.
1	+.703
2	+.637
3	+.614
4	+.635
5	+.590
6	+.533
7	+.498
8	+.493
9	+.492
10	+.491
11	+.441
12	+.415
13	+.398
14	+.394
15	+.348
16	+.329
17	+.289
18	+.297
19	+.311
20	+.272
21	+.228
22	+.191
23	+.176
24	+.199
25	+.140
26	+.106
27	+.101
28	+.116
29	+.086
30	+.023

Autocorrelation coefficient

Figure 5: Graph of autocorrelation function

In case of researches of causality between two psychological dimensions in a multidimensional model, the computation of *cross-correlation* coefficient traduces the dependence degree between two time series. It is a correlation including successive couples of synchronic values in two time series (x_t and y_t). The *cross-correlation* coefficient is then computed with the introduction of time lags between both series. This function determines lag corresponding to maximal dependence between two variables, suggesting influence of a series to the other with a certain time lag. The sign indicates the direction of this influence. If evolution of time series X precedes similar evolution of series Y, then the conclusion is that changes of Y depends change of X. The figure 6 presents a cross-correlation graph from two time series without lag because the higher coefficient (.60) is obtained at lag 0 (Shumway & Stoffer, 2000). These series can be windowed to determine certain causalities during certain periods of time series (Boker, Xu, Rotondo & King, 2002; Gernigon, d'Arripe-Longueville, Delignières & Ninot, 2004).

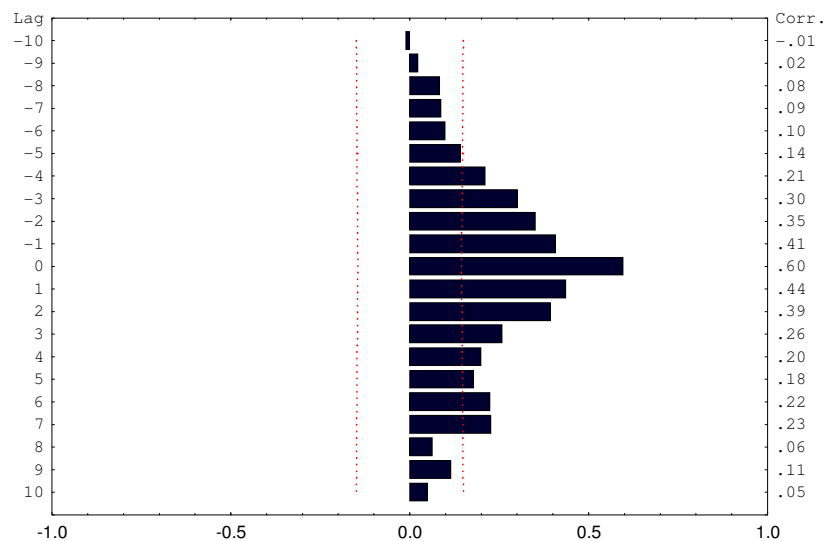| Lag	Corr.
−10	−.01
−9	.02
−8	.08
−7	.09
−6	.10
−5	.14
−4	.21
−3	.30
−2	.35
−1	.41
0	.60
1	.44
2	.39
3	.26
4	.20
5	.18
6	.22
7	.23
8	.06
9	.11
10	.05

Figure 6: Graph of cross-correlation function

To determine the dynamics of a time series of 50 to 500 observations, *Auto-Regressive Integrated Moving Average* (ARIMA) procedures are proposed by Box and Jenkins (1976). These procedures aim to establish how each value in the series depends on preceding values (iterative pattern) and then to tentatively infer psychological processes underlying the time evolution of the series (Spray & Newell, 1986; Fortes, Ninot & Delignières, 2005). ARIMA procedures constitute a very basic and commonly used time series analysis method especially in econometrics, and are available in most statistical packages (Shumway & Stoffer, 2000). Nevertheless, the method remains unfamiliar to many psychologists. The aim of these procedures is to model the dynamics of time series in form of iterative equation:

$$y_t = f(y_{t-1}) \qquad\qquad (1)$$

where y_t represent the value observed at time *t*.

These procedures are based on the study of ACF and partial autocorrelation functions (PACF), which inform about the temporal dependence in the series. An ARIMA model is composed of the potential association of three types of mathematical process: auto-regressive (AR), integrated (I) and moving average (MA) processes. The model is labeled as (*p,d,q*) where *p* indicates the number of auto-regressive terms, *d* the number of differentiations, and *q* the number of moving average terms.

The first step in ARIMA procedures is the determination of the number of differentiations to include in the model in order to account for the general trends of the series. The determination of the number of differentiations to include is based on the examination of the ACF of the original series.

If the original series is stationary (i.e., presents a constant mean over time), no differentiation is necessary. The ARIMA model (0,0,0) constitutes a dynamics characterized by the following equation:

$$y_t = \mu + \varepsilon_t \qquad\qquad (2)$$

where μ represents the mean of the time series. This process characterizes random oscillations around a reference value over time. The series appears quite choppy because of the uncorrelated adjacent points. This process is stationary since the mean of the series is constant and does not depend on time. A white noise model has sometimes been encountered in motor learning research. This model was found to represent some series of successive motor task performances with knowledge of results (Spray & Newell, 1986). Psychological interpretation of such models lies on the stationarity of the mean which suggests that individuals develop a stable reference around which responses randomly fluctuate. As previously explained, the personality *trait* hypothesis related to self-esteem suggests that its functioning would be characterized by a (0,0,0) model as the stable referenced value associated with weak and random fluctuations. Similarly, the time series of measurement error item should evolve around a mean whose value should correspond to the center of the line.

The presence of positive and persistent autocorrelations (up to 10 lags, for example) implies the need to introduce at least one differentiation term in the model. Then, the ACF of the differenced series (i.e., the series of successive differences in the original series) is examined. The persistence of significant autocorrelation in this differenced series suggests that a second differentiation term might need to be introduced in the model. Conversely, the appearance of one significant negative autocorrelation at the first lag suggests that the series has been over-differenced. This first step allows the estimation of parameter *d* of the ARIMA model. A differentiation of order 1 accounts for a linear trend in the series, noted (0,1,0), can be expressed as follows:

$$y_t = y_{t-1} + \mu + \varepsilon_t \tag{3}$$

where y_t is the value observed at time t, μ is a constant that represents the average difference between adjacent values in the original series, and ε_t is a white Gaussian noise. More complex trends may be modeled by a second-order differentiation. As previously explained, the (0,1,0) model without significant constant characterizes psychological *state* functioning over time. This model is typical of time series that exhibit sensitivity to local events (immediate experience). The current value is determined by the preceding value (y_{t-1}), plus the current disturbance (ε_t) or local event (or random shock) that impacts either positively or negatively. The process is a dependency to change. The process leads to a substantial evolution in the local mean of the series under the influence of life events.

The second step aims at identifying the autoregressive and moving average terms to include in the model, through examination of the ACF and PACF of the (stationarized) series. An AR process suggests that the current value is determined by a weighted sum of the preceding values. For example, an AR process (1,0,0) obeys the following equation:

$$y_t = \mu + \phi \, y_{(t-1)} + \varepsilon_t \tag{4}$$

where μ is a constant, ϕ is the auto-regressive coefficient, and ε_t is the error associated with the current value. The typical signature of an AR process is a slow decay of the ACF and a sharp cut-off of the PACF, which presents a limited number of significant peaks. The number of significant correlations in the PACF indicates the number of AR terms to include in the model. If μ is not significant, the model (1,0,0) is related to constant adaptation to events over time. The autoregressive model characterizes psychological *dynamical equilibrium* functioning over time. This model with significant constant is typical of time series that exhibit homeostasis functioning. The current value is determined by a constant μ that represents the average of the original time series (referenced value), the preceding weighted value (y_{t-1}), and the local disturbance (ε_t). The amplitude of oscillation is given by ϕ. The functioning is stable associated with random fluctuations and relaxation oscillations.

A moving average (MA) process suggests that the current value is determined by the weighted average of the preceding values. When the series is considered to be stationary, this process can also be defined as the sum of the mean of the series plus the weighted sum of the errors associated with the preceding values. Thus an MA process of order 1 obeys the following equation:

$$y_t = \mu - \theta \, \varepsilon_{(t-1)} + \varepsilon_t \tag{5}$$

where μ is the mean of the series, θ is the moving average coefficient and ε_t is the error associated with the value at time t. The typical signature of an MA process is a slow decay of the PACF and a sharp cut-off of the ACF. The number of significant correlations in the ACF indicates the number of MA terms to include in the model.

The resulting models are constituted from the combination of the basic equations previously presented. For example, an ARIMA model (0,1,1) obeys the following equation:

$$y_t = \mu + y_{(t-1)} - \theta \, \varepsilon_{(t-1)} + \varepsilon_t \tag{6}$$

which contains one differentiation term and one moving average term. Such a model allows the description of the progressive evolution of the series and an inference concerning the underlying psychological functioning. The obtained models are submitted to a multi-criteria evaluation: (1) each coefficient in the model should be statistically significant, (2) the residuals should represent a white noise process without any time dependence, and (3) the standard deviation of the residuals should be lower than the standard deviation of the original series (Box & Jenkins, 1976).

The application of the ARIMA procedures provided interesting statistical results, and a quite reasonable model of the psychological processes underlying the dynamics (Fortes *et al.*, 2005).

Nevertheless, this approach tends to focus on short-term correlations in the series, and is unable to reveal more complex dynamics, as for example longer-term time dependencies.

Fractal analysis methods are devoted to determine long term correlations, for time series more than 1024 observations. The duration of assessment is decided to optimize spectral analyses, which work on the basis of series with lengths that are powers of 2. The methods detect the presence of fractal processes underlying the dynamics of time series. A number of methods have been proposed for assessing the scaling exponent of fractal series (Eke, Herman, Bassingthwaighte, Raymond, Percival, Cannon, Balla & Ikrényi, 2000; Scheppers, van Beek, & Bassingthwaighte, 1992). Eke *et al.* (2000) proposed methodological principles to apply these analyses. The methods are explained in details in our specific paper (Delignières, Fortes & Ninot, 2004).

A DYNAMICAL APPROACH TO DETERMINE
SELF-ESTEEM FUNCTIONING

Example of self esteem time series

An idiographic protocol can be a daily measurement of self-esteem over a two months period. It permits to obtain a time series of 60 consecutive observations. The researcher will determine not only the nature of events but also median level (*mean* during the period), instability (*standard-deviation*, *range*, *mean of absolute difference* between two consecutive days) and the dynamics. An illustration is presented with a young woman with moderate anorexia particularly unstable and with a dynamic with a low process of preservation (figure 7).
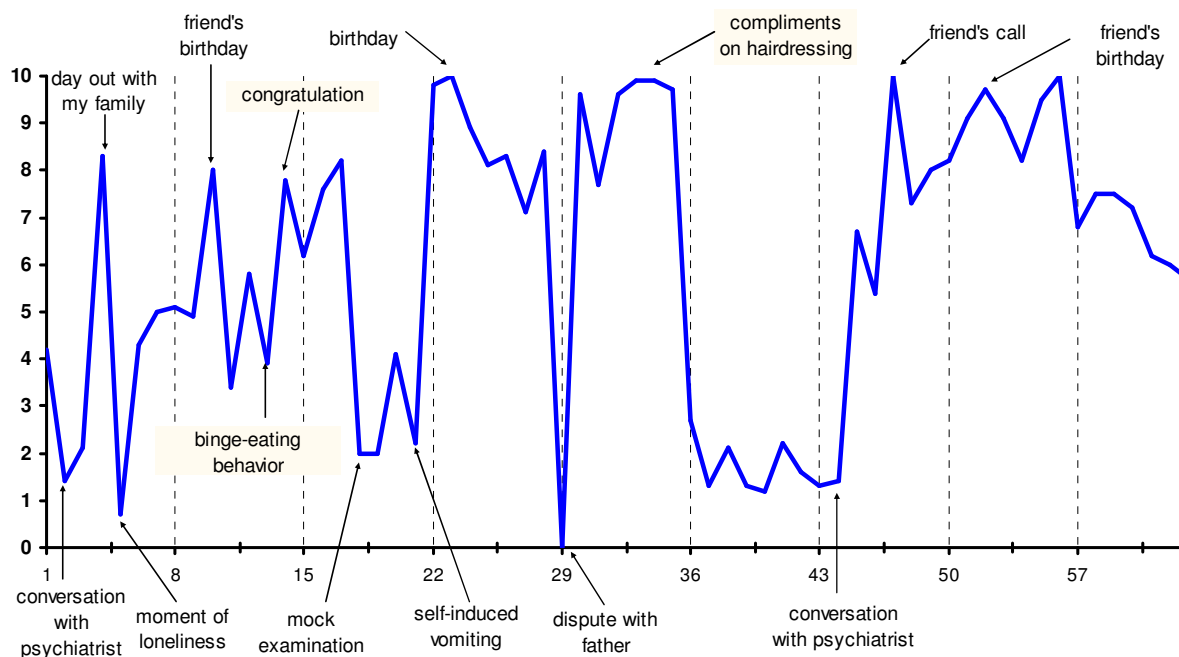

Figure 7: Daily change of self-esteem in a young anorexic adult (0 *not at all* and 10 *absolutely*)

Functioning of self-esteem

Mean and instability

The first hypothesis was that the means but not the instability such as standard deviations of self-esteem measured twice a day would be similar over two consecutive periods of six months in healthy adults (Ninot, Fortes, Delignières & Maïano, 2004). Each participant completed a PSI twice

a day between 7:00 and 9:00 am and between 7:00 and 9:00 pm over one year period. Each inventory included one item for self-esteem, and one for the measurement error. The individual time series presented 728 observations. The figures 8 and 9 respectively show two times series of man aged of 42 years and woman aged of 29 years.
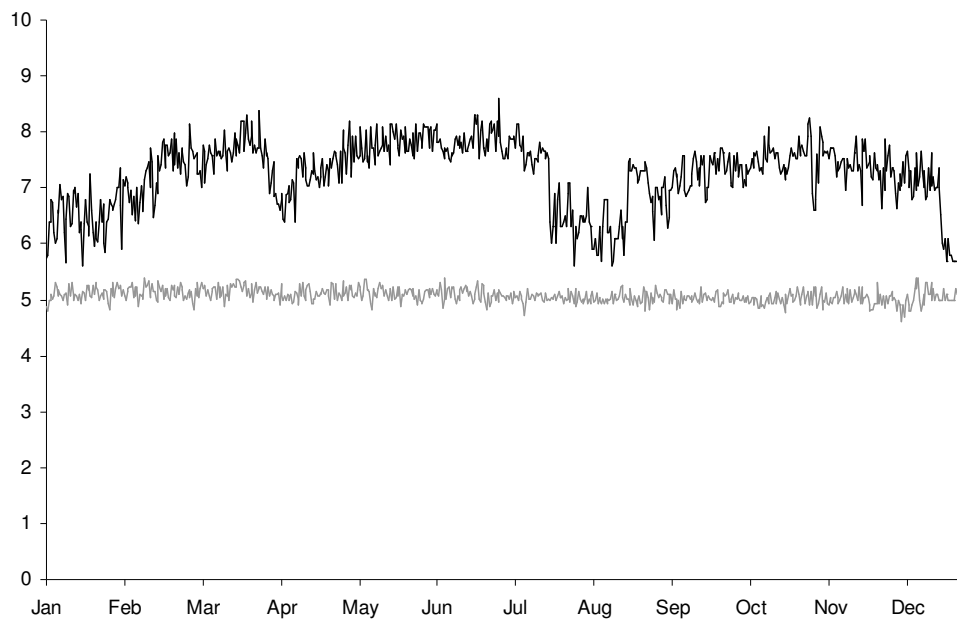

Figure 8: Bi-daily change in self-esteem (upper curve) and measurement error item (lower curve) in a man over the year 2001
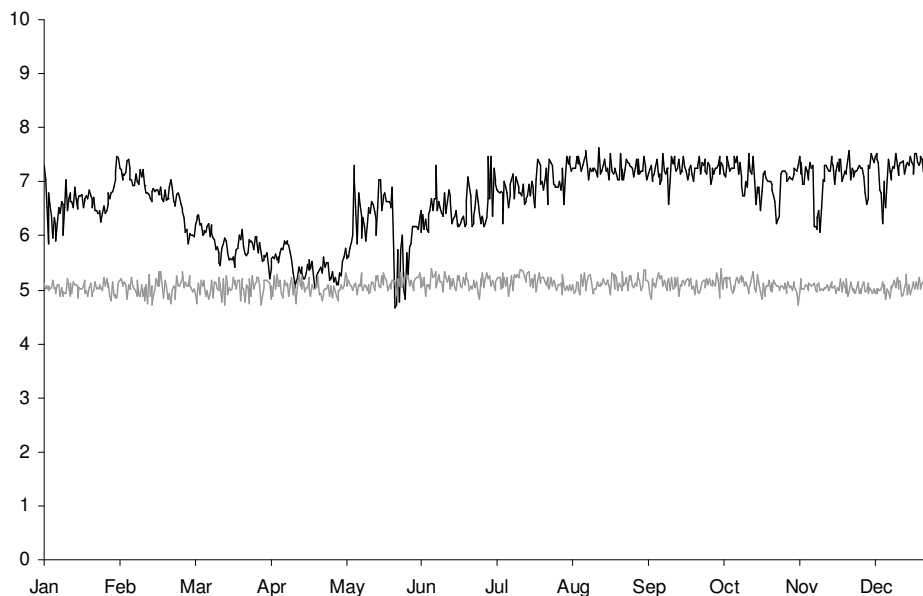

Figure 9: Bi-daily change in self-esteem (upper curve) and measurement error (lower curve) in a women over the year 2001

Table 2 presents the descriptive results over the two consecutive periods of six months. The paired *t*-test reveals no differences in the mean score of self-esteem between the two semesters. The paired *t*-test reveals standard deviation of self-esteem significantly higher for semester 1 compared to semester 2 ($p < .05$).

			A(M)	B(M)	C(M)	D(M)	E(W)	F(W)	G(W)	H(W)	*p*
	Sem 1	M	5.08	5.07	5.07	5.08	5.10	5.08	5.08	5.08	
ME		SD	0.12	0.12	0.16	0.12	0.13	0.12	0.13	0.12	
	Sem 2	M	5.04	5.04	5.01	5.06	5.05	5.04	5.09	5.04	0.50 ($t = 0.70$)
		SD	0.11	0.11	0.16	0.11	0.11	0.10	0.12	0.11	0.11 ($t = 1.77$)
	Sem 1	M	9.11	8.36	7.24	7.43	5.18	7.49	6.67	6.25	
GSE		SD	0.47	0.84	0.60	0.53	1.08	0.54	0.66	0.85	
	Sem 2	M	9.37	8.66	7.10	7.49	5.37	7.10	7.13	5.58	0.95 ($t = -0.06$)
		SD	0.29	0.75	0.59	0.54	0.69	0.44	0.28	0.25	0.03 ($t = 2.84$)

Note. W = woman; M = man; ME = measurement error item; GSE = global self-esteem; Sem = semester.

Table 2: Descriptive values of global self-esteem and physical self over two consecutive semesters

Adults present stable mean scores of self-esteem between two consecutive periods of six months. The individual systems of self-perception maintained globally their scores over a period of one year.

However, graphs and descriptive data showed global and local instabilities of self-esteem, more than measurement error item. The significant difference in the standard deviation of self-esteem scores indicated that these adults reduced their fluctuations during the second semester. The presence of instabilities of self-esteem tied to specific external events such as success or failure. The results support fluctuations evidenced by Kernis and his collaborators in self-esteem ratings (Kernis, 1993; Kernis & Waschull, 1995; Greenier *et al.*, 1999). Self-esteem appears to be sensitive to daily events (Nezlek & Plesko, 2001), and its instability reflect the reactivity of each individual to these events. Individuals tend to experience slight variations rather than dramatic shifts in their self-evaluations (Kernis, 1993; Kernis *et al.*, 1989; Kernis *et al.*, 1991).

More generally, *standard-deviation*, *range*, *mean of absolute difference* are sensitive to different features of variability in the time series and our results showed that they represent quite independent characteristics (Fortes, Delignières et Ninot, 2004b; Ninot *et al.*, 2004). The *standard deviation* reflects the global sensibility of the series. The *range* is related to the excursion to extreme values during self-assessments. The *mean absolute difference* informs on the local sensitivity to daily disturbances. Each subject seemed to be characterized by a particular combination of these three properties. This suggests the hypothesis of a type of individual dynamic invariant that would consistently underlie self-evaluative behavior.

Nevertheless, the descriptive indicators of variability were insufficient to determine the psychological process that produces self-esteem perception.

Short term dynamics

One of our study assessed intra-individual dynamics of self-esteem in healthy adults over a six-month period (Ninot *et al.*, 2005). The purpose was to examine over time the suppositions offered by nomothetic researches about the dynamics of self-esteem (see 1.1.3). The hypothesis was that the self-esteem functions as a *trait* over a six-month period in adults.

The participants were eight adults, four women and four men (mean age: 29.4 years; SD: 7.9; SEM: 2.8). They were all employed, came from middle-class backgrounds, and none lived alone. None had pharmacologically treated psychiatric disorders or severe medical illness and none

had recently undergone major negative life events that would have affected psychological functioning over the six-month period. All gave informed written consent to participate.

All time series of global self-esteem present long-trend ACF. Each of them exhibits significant and progressive decline in ACF coefficients from lag 1 to the maximal significant lag ($p < .05$). This assumes that the original series are non-stationary and have a constant average trend. Moreover, the better and significant ACF coefficient is always found at lag 1. Conversely, ACF and partial ACF of each measurement error item time series do not exhibit for any lag significant coefficients. Thus, the best ARIMA model for measurement error item time series is systematically a (0,0,0) model which is characterized by the equation (2).

To determine the best fitted ARIMA model for self-esteem time series, differencing procedures were performed for all series to make them stationary. Time series presenting a long-trend ACF underwent a first order differencing. The lag 1 autocorrelation of the differenced series satisfied requirements, thus indicating that no further differencing was necessary. As a result, all the models were (p,1,q) models, suggesting that the original series were not stationary and had constant average trends. No significant constants were found and the standard deviations were reduced, indicating that the trends had been completely eliminated. The autocorrelation function of the differenced series displayed a sharp cutoff while the partial ACF decayed slightly (i.e., had significant spikes at higher lags), thus suggesting a MA signature. The MA model (0,1,1) without significant constant was systematically obtained for all of the differenced time series ($p < .001$). All the time series presented the same MA dynamics with specific θ coefficient from 0.47 to 0.81, thus characterizing the time functioning as not stationary, and with short-term autocorrelation. The time series must not be considered as white noise fluctuations around a stable value.

The *trait* hypothesis was that self-esteem dynamics were only related to measurement error, suggesting that individuals actively resist to change and return to a reference value. The results showed clearly that the eight self-esteem time series fluctuated over the six-month period, more than the time series resulting from the measurement error item. The self-esteem time series were not stationary or random. The significant autocorrelation, including a progressive decrease, indicated that the process of self-esteem functioned with a short-term history for each participant. Using repeatedly a sensitive instrument over a long period showed that self-esteem can be considered as a complex dynamical system subjected to internal and environmental constraints (Nowak *et al.*, 2000). It cannot be considered as white noise fluctuations around a stable value.

The ARIMA procedures showed systematically MA model associated with first order differencing and a non-significant constant (0,1,1) characterized by equation 6 without significant constant ($\mu = 0$). The system did not oscillate around one reference value, and/or it did not tend to come back to this reference after a perturbation. The system exhibited noisy fluctuations around a slowly varying mean.

Conversely, the (0,0,0) model, characterized by random fluctuation around a reference value corresponding, was systematically obtained for measurement error item ($\mu = 5$). In a closed room without stimulation over a period of four hours and 15 minutes (completion each 5 minutes), we obtained 88% of self-esteem times series related to white noise fluctuations around a defined value and 12% of the time series functioned as an MA (0,1,1) model (Ninot *et al.*, 2004). This suggests that individuals actively resist change and return to a local reference value under conditions of a confined environment with no interruption.

In ecological context, the *trait* hypothesis had to be rejected. Self-esteem cannot be an attractor that functions as *trait* over time. Self-esteem measured over time did not function as a real *state* or *dynamic equilibrium*.

The pattern (0,1,1) of self-esteem emerges from an organic system confronted by several constraints. The time series has a specific sense over a short time period. The assessment at time t is characterized by an error term (ε_t), mathematically considered as a random disturbance.

Psychologically, this disturbance should be considered as the resultant (perceptible and/or imperceptible) of all the recent (good or bad) events likely to affect the assessed dimension. The value at time t is modeled as the preceding observed value (y_{t-1}) minus a fraction of its own disturbance $(\theta\varepsilon_{t-1})$. In other words, the value at time t tends to absorb the preceding disturbance. The amplitude of the correction is given by θ, and the restoration should be complete with a θ value close to 1. This correction underlies the preservation process, which limits the influence of the perturbations, and ensures the stability of the series.

Mathematically, the first part of the MA equation $(y_t = y_{(t-1)} + \varepsilon_t)$ proposes individual iterative functioning based on history over a short period that generates adaptation to the impact of preceding and current events. The second part of the MA equation $(-\theta\varepsilon_{(t-1)})$ is related to preservation function, corresponding to a fraction of the measurement error emerging from the previous auto-evaluation (a sort of correction of previous adaptation).
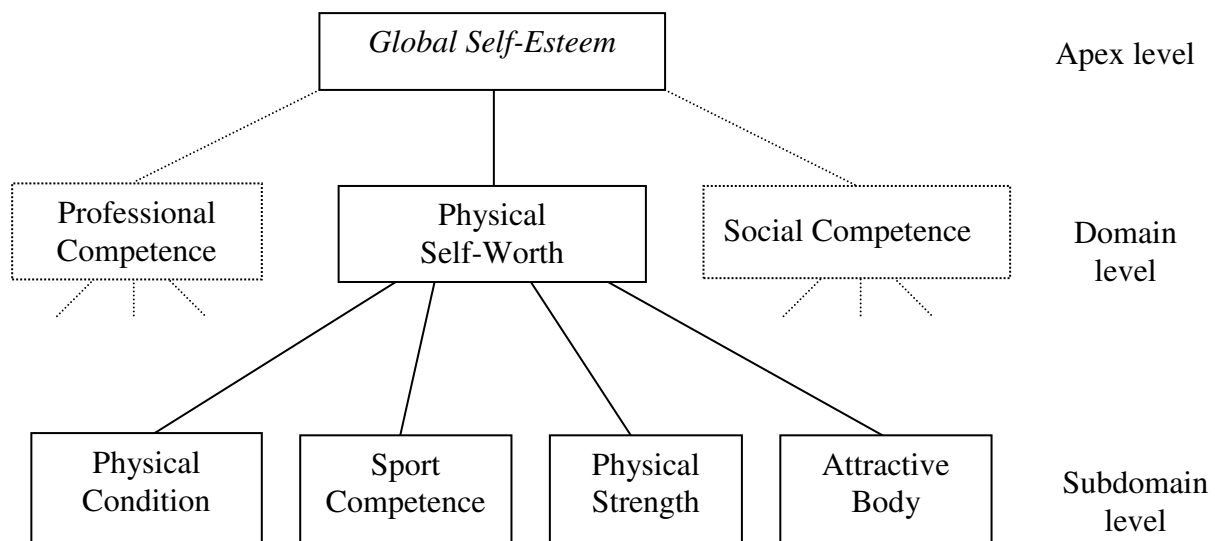
Psychologically, this model suggests that the dynamics of self-esteem could be underlain by the combination of two opposite processes: an *adaptation* process, which tends to inflect the series in the direction of the perturbation, and a *preservation* process, which tends to restore the previous value after disturbance (functioning as a resistance to the influence of daily events). For *adaptation* process, the inclusion of incoming information is well-known (Butler, Hokanson & Flynn, 1994; Nezlek & Plesko, 2001; Rosenberg, 1979). For *preservation* process, the importance of maintaining relatively stable and positive self-evaluation despite a high number of negative events that may affect stability of self has been clearly demonstrated in the literature (Sedikides & Skowronski, 1997; Tesser & Campbell, 1983).

The ARIMA model (0,1,1) was obtained in several occasions (Fortes *et al.*, 2004b; Delignières *et al.*, 2004; Ninot *et al.*, 2004). The combined effects of these two processes led to a local reference value that evolved slowly under the influence of life events. These results indicate that a *dynamic adjustment* governs changes in global self-esteem. According to Marks-Tarlow (1999), self-esteem can be viewed as a continuous flow that is beyond contextual, social, and cultural factors. This global self-perception emerges from a system possessing enough stability to maintain consistent functioning, but sufficient randomness to ensure adaptability and creativity. The analysis of its historical evolution is essential to understanding it (Marks-Tarlow, 1999).

The coefficient θ is generally far from 1. We reported values ranging from 0.40 to 0.86, and as such a residual fraction of the previous disturbance remains in the current expected value. In other words, each disturbance tends to leave a persistent trace in the dynamics of the series. The moving average coefficient θ determines the balance between these two opposite processes. We evidenced a high consistency between the coefficients obtained for the different time series of a given participant (Fortes *et al.*, 2004b; Ninot *et al.*, 2004). This suggested a kind of individual characteristic related to the stability of self-esteem and its resistance to the influence of daily events. From a clinical point of view, the closer the θ coefficient was to 0, the less conservative the system was and the less it resisted to environmental stimuli. The low θ coefficient reflected low historical consistency, which can be interpreted as unstable self-esteem, fragile and vulnerable self-worth, an over-dependence on the love and approval of significant others, a heightened tendency to be ego-involved in every day activities, excessive dependency needs, over-reliance on the evaluations of others, and an impoverished self-concept (Butler et al., 1994; Kernis *et al.*, 1989; Rosenberg, 1979; Tennen & Affleck, 1993; Greenier *et al.*, 1999).

More interestingly, we applied the same ARIMA procedure to the hierarchical structure of physical self (figure 10) in many healthy adults. We obtained the same common dynamics (0,1,1) over different periods (Delignières *et al.*, 2004; Fortes *et al.*, 2004b; Ninot *et al.*, 2004). This homogeneous dynamics in the physical self and global self-esteem suggests that the different dimensions in the model share a common dynamics. This suggests that an invariant individual dynamics would consistently underlie self-evaluative behavior. Biological systems are often

characterized by spontaneous behaviors having a high level of stability and reproducibility (Kelso, 1995). The similar pattern suggests that the intra-individual dynamics of self-perceptions were stable over time. This tendency reveals the presence of attractors linked to the dynamics of self. Research is needed to explore this hypothesis within specific impacts (Marks-Tarlow, 1999; Ninot *et al.*, 2004; Nowak *et al.*, 2000).

Note: Fox and Corbin (1989) proposed a hierarchical model for the physical domain of competence that has been empirically supported by studies throughout the Western world (e.g., Sonstroem, Speliotis, & Fava, 1992). The median level of the physical self is occupied by physical self-worth, which can be seen as a general feeling of happiness, satisfaction, pride, respect, and confidence in the physical self. The most specific level is composed of four sub-domains: physical condition, sport competence, physical strength, and attractive body. Physical condition represents the perception of one's physical condition, fitness and stamina, one's ability to maintain exercise, and one's confidence in the exercise and fitness settings. Sport competence corresponds to the perception of sport and athletic ability, ability to learn sport skills, and confidence in the sport environment. Physical strength is related to perceived strength, muscle development, and confidence in situations requiring strength. Finally, attractive body corresponds to the perceived attractiveness of the body, the ability to maintain an attractive body and confidence in one's appearance.

Figure 10: Hierarchical model of self-esteem within physical domain particularly developed (Fox & Corbin, 1989)

The application of the ARIMA procedures provided interesting statistical results and a quite reasonable model of the psychological processes underlying the dynamics of self-esteem. The system exhibited noisy fluctuations around a slowly varying mean. Nevertheless, this approach tends to focus on short-term correlations in the time series and is unable to reveal longer-term dependencies, which could be indicative of the presence of fractal processes in the time series. Investigating self-esteem as an emergence of a complex dynamical system leads to a variety of insights regarding self-structure and self-process.

Long term dynamics

Several theoretical and empirical arguments lead to put forward the hypothesis of the presence of chaotic or fractal processes underlying self-esteem time series. Most of the contemporary models of self-esteem consider this construct as multidimensional. Marks-Tarlow

(1999) argued that each level of the self is formed through interactions and complex feedbacks loops occurring at various physiological, psychological, and social levels. Each level possesses an emerging dynamics, and is embedded in the next, giving rise to fractal properties such as self-similarity. In the same vein, Nowak *et al.* (2000) considered self-esteem as an emergent property of a complex dynamical system, composed of a myriad of specific and interconnected self-thoughts. From this viewpoint, the emergence of self as a coherent structure and its maintenance facing incongruent elements can be understood as the result of a process of self-organization, on the basis of the multiple interactions acting within the system. The macroscopic behavior of such complex dynamical systems was frequently proven to exhibit fractal properties (Bak & Chen, 1991; Gilden, 2001; West & Shlesinger, 1990).

The examination of the ACF of self-esteem series and physical self, in previous studies (Fortes *et al.*, 2004b; Ninot *et al.*, 2001; 2004; 2005), reveals the persistence of significant autocorrelation over a wide range of lags (up to 100 lags in some time series with more than 500 observations). These results suggest the presence of long-term time dependencies in the time series.

Another argument relates to the inherent stability of such fractal processes. A number of biological and psychological time series were recently proven to possess fractal properties. Recent research evidenced this kind of results in continuous uni-manual tapping (Chen, Ding, & Kelso, 2001), in serial reaction time (Gilden, Thomton, & Mallon, 1995), in step duration series during locomotion (Hausdorff, Mitchell, Firtion, Peng, Cudkowicz, Wei, & Goldberger, 1997) or in heartbeats (Goldberger, 1999). When obtained from young and healthy organisms, these time series exhibit a very special case of fractal behavior, called 1/*f* or *pink* noise. "1/*f* noise" signifies that when considering the power spectrum of these time series, each frequency has power proportional of its period of oscillation. As such, power is distributed across the entire spectrum, and not concentrated at a certain portion. Consequently, fluctuations at some time scale are only loosely correlated with those of another time scale. This relative independence of the underlying processes acting at different time scales suggests that a localized perturbation at one time scale will not necessarily alter the stability of the global system. In other words, 1/*f* noise renders the system more stable and more adaptive to internal and external perturbations (West & Shlesinger, 1990).

One can easily understand why fractal behavior constitutes an appealing hypothesis for modeling the dynamics of self-esteem time series. Four adults volunteered for this study (Delignières *et al.*, 2004). All were employed, and came from middle-class backgrounds. None had pharmacologically treated psychiatric disorders or severe medical illness and none had recently undergone major negative life events that would have affected psychological function over the testing period. They were not paid for their participation. Each participant completed the questionnaire on computer twice a day over a period of 512 consecutive days. Participants were not informed of these numerical scores, and were not allowed to consult their previous responses. We finally obtained 1024-point time series, for each dimension and each participant. The duration of the experiment was determined in order to optimize spectral analyses, which work on the basis of series with lengths that are powers of 2.

The main result is the uncovering of long-range, fractal correlation in self-esteem time series (Delignières *et al.*, 2004). The fractal behavior of the series was proven without ambiguity, with consistent results obtained by different methods, one in the frequency domain, and three in the time domain. The results give a good illustration of the interest of an integrated approach in fractal analysis, by the joint use of different methods, not only for detecting the presence of fractal processes, but also for the estimation of the scaling exponents (Rangarajan & Ding, 2000).

The uncovering of long-range, fractal correlation in self-esteem series led to important theoretical considerations. Such fractal behavior, at a systemic level, is generally considered as the expected outcome of a complex, dynamical system, composed of multiple interacting elements (West & Shlesinger, 1990). Long-range correlations constitute the typical signature of complex systems in critical self-organized state (Bak & Chen, 1991). Multiscaled randomness could under

some conditions give rise to such behavior (Hausdorff & Peng, 1996). All these propositions share the idea of the presence of many interacting components acting on different time scales. As such, our results represent an interesting support for the theory proposed by Nowak *et al.* (2000), which considered self-esteem as a self-organized dynamical system.

Interestingly, this fractal behavior was discovered, with similar scaling exponents, for each dimension in the hierarchical model of physical self. On the basis of the principles underlying the hierarchical model of physical self (Fox & Corbin, 1989), one could conceive self-esteem as more complex (i.e. integrating a wider number of elements) than the others dimensions. Our results associated to those with ARIMA analyses suggest that sub-domains behave in a similar way than the higher and more global levels, and should also be considered as complex systems. This result is consistent with the basic principles of self-similarity, each level in the self appearing to contain similar dynamics, while being embedded in the next level (Marks-Tarlow, 1999).

The exponents obtained for each series allowed us to classify them as close to $1/f$ noise. This noise represents a compromise between white noise and Brownian motion. More precisely, $1/f$ noise represents a compromise between the absolute preservation of the mean achieved by white noise (which is characterized by a strictly stationary series, with random fluctuations around a stable mean), and the absolute adaptation of Brownian motion (defined as the cumulative sum of a series of random shocks).

These results have important implications, concerning the way one can conceive functioning of self-esteem. When $1/f$ noise was discovered in a number of young and healthy systems, each frequency of these time series has power proportional of its period of oscillation. Power is distributed across the entire spectrum, and not concentrated at a certain portion. Consequently, fluctuations at some time scale are only loosely correlated with those of another time scale. This relative independence of the underlying processes acting at different time scales suggests that a localized perturbation at one time scale will not necessarily alter the stability of the global system. $1/f$ noise possesses an intrinsic stability, due to the relative independence of the underlying processes acting at different time scales. In other words, $1/f$ noise renders the system more stable and more adaptive to endogeneous and exogeneous perturbations (West & Shlesinger, 1990). This "optimal" fractality appears as the typical signature of young, healthy, and adaptive systems. On the contrary, certain diseases seem associated with a disruption of this "optimal" fractality (West & Shlesinger, 1990). Hausdorff *et al.* (1997) showed that fluctuations in the duration of the gait cycle display $1/f$ behavior in healthy young adults. This fractal dynamics was systematically altered with elderly subjects or with subjects with Huntington's disease. In these cases, fluctuations appeared more random, closer to a white noise process. In the same vein, Goldberger (1999) analyzed beat-to-beat fluctuations in heart rate and showed that a congestive heart failure led to an alteration of the $1/f$ fractality observed for healthy subjects. In these two experiments the amplitude of the alteration was proportional to the severity of the disease.

Implications

Dynamics of self-esteem

The application of time series analyses to self-esteem and physical self series constitutes only a first step in the characterization of their functioning. Nomothetic researches proposed finally a simplification of intra-individual functioning of self-esteem and quick generalization. Reductionism, determinism and epistemological orientations can explain these simplifications. Dynamical social psychology opens a new perspective in considering self-esteem functioning. Successive ecological constraints are needed to understand psychological processes implicated to self-esteem emergence. These random impacts cannot be ignored as a *trait*, assimilated as a *state*, or fixed to a reference value as a *steady state*. The results did not show an increase of entropy. The constraints are progressively integrated with the process called *dynamic adjustment*. The local mean

evolves slowly with random impacts. Everything functions as if equilibrium of self-esteem is found with the disequilibrium caused by ecological constraints, as dissipative structure that needs energy to "exist" (Prigogine, 1994). This functioning differs to a major Piagetian principle that stipulates: equilibrium of life organism is a pseudo-equilibrium dynamic due to multitude of disequilibrium naturally compensated for. The observed process far to the equilibrium needs random impacts and permits a great flexibility without neglecting own history. It is a fundamental condition to create new behaviors. In consequence, studying exclusively the level score a t time is insufficient and very approximate to determine self-esteem of a subject, whatever the final aim. Studying instability and dynamics is indispensable to understand the functioning and provide validity to mean level.

The 1/f behavior we evidenced could be conceived as the typical intrinsic dynamics of self-esteem and physical self for healthy, physically and professionally active adults. According to Marks-Tarlow (1999), psychological health resides at the edge of chaos, a transition zone between predictable order and unpredictable chaos. Within this zone, systems possess enough stability for maintaining a consistent functioning, but sufficient randomness to ensure adaptability and creativity. Disabled systems behave away from this edge, in the direction of unpredictable chaos, as in hysterical patients, or in the opposite direction of deterministic order, as in obsessive-compulsive patients. Marks-Tarlow (1999) predicts that for such patients, specific alterations of fractality should be observed, in the direction of Brownian motion in the first case, and in the direction of white noise in the second. Gottschalk, Bauer and Whybrow (1995) evidenced such results in the close domain of mood variation. They analyzed long-term daily mood records in bipolar disorder and normal subjects, and observed in both groups a 1/f-type noise in the collected series. ß exponents were significantly higher in bipolar disorder patients, suggesting that self-rated mood in such patients was more organized, and characterized by a loss of complexity.

One of the most important results is the demonstration of the non-stationary nature of self-esteem over time. Such non-stationary processes could be characterized by a number of features, including changes in the dynamics, or bifurcations. Such phenomena could be especially expected in chronic disease patients (Ninot, Fortes, Leymarie, Brun, Poulain, Desplan & Varray, 2002). But, some specific episodes could entail local changes of self-esteem dynamics in healthy persons (see figure 8 and 9).

Our studies support to the conception of the self as a complex dynamical system (Nowak *et al.*, 2000; Vallacher *et al.*, 2002). The fractal behavior reflects intrinsic dynamics of self-esteem and physical self of healthy adults, and its inherent properties could explain some macroscopic, commonly recognized features, such as stability, preservation, or adaptation. Further studies are needed with ecological and experimental viewpoint in different individuals to detail combination of processes.

Functioning of multidimensional models

Theoretical conceptualizations of self-esteem have changed markedly. Self-esteem was first conceived as a one-dimensional and global construct (Coopersmith, 1967; Rosenberg, 1979), namely the individual's overall sense of worth as a person. More recently, multidimensional models were developed on the basis of evaluative statements, with self-esteem seen as the combination of distinct self-assessments relative to specific domains of competence (Harter, 1985). These models were then enriched by the introduction of hierarchical conceptions (Fox & Corbin, 1989; Marsh & Shavelson, 1985) that allowed direct focus on mechanisms of change in the self-system. Several domains of competence seem to be implicated in self-esteem enhancement, particularly the physical domain (Fox & Corbin, 1989; Marsh & Yeung, 1998; Sonstroem *et al.*, 1992). According to these hierarchical conceptions, global self-esteem is at the apex of the structure and is then linked to first-order facets (e.g., academic self-concept, physical self-concept), themselves composed of second-order facets (e.g., math competence or sport competence).

(In)stability in self-perception hierarchical structure remained unknown. According to several authors (Buckworth & Dishman, 2001; Fox, 1990), (in)stability of global self-perception reflects self-consistency, with the development of feelings of unity, independence, predictability, and control. The lowest levels will undergo stronger variations resulting from situational experiences than the higher levels. The assumption is that meaningful changes in self-esteem from an activity might be difficult to detect because the global scale lacks the necessary sensitivity. Changes would be detected at the specifically relevant subscale. Other authors (Amorose, 2001; Brown, 1998; Marsh & Yeung, 1998) found that responses to global self-concept scores were unstable in comparison with specific physical scales. Global self-evaluations are more affected by mood and immediate experiences, and therefore are likely to vary more over time (Brown, 1998). The assumption is that the lowest level would be the most specific and stable because specific abilities cannot radically change in just a few days. Conclusions of these studies were based on theoretical supposition or longitudinal protocols with fewer than six measures performed over unequal periods (3 weeks to 18 months). Moreover, some studied adolescents, who are considered to be less stable than adults (Rosenberg, 1979).

Descriptive indicators of (in)stability and cross-correlation function allowed us to test this hypothesis concerning the relative stability of each dimension in the hierarchical model. The results did not reveal any evidence of a higher or lower (in)stability for the apex level as compared with the more specific dimensions (Fortes *et al.*, 2004a; Ninot *et al.*, 2004). This intra-individual homogeneity was evidenced for the three indicators of instability (standard deviation, range, and mean absolute difference) and cross-correlation function (Fortes *et al.*, 2004a). Each participant were characterized by a particular combination of these three properties whatever the hierarchical level. A maximum centered on lag zero of cross-correlation function was obtained. (In)stability appeared quite consistent for each subject among dimensions, whatever the position of these dimensions in the hierarchical model of physical self. This homogeneous (in)stability in the self-concept system constitutes a surprising result and suggests that the different dimensions in the model share common dynamics. This also suggests a strong coupling between the dimensions, characterized by a synchronic evolution over time.

Causal flow in hierarchical models

The conception of self as a hierarchical structure led researchers to question the mechanisms of change across the self-system. Based on individual-environment interactionism and situation-specific constructs, hierarchical self-concept was thought by some to generalize from situation-specific experiences. This perspective emphasizes the role of cognitive processes, with self-esteem seen as the result of judgments about one's qualities in various domains (Harter, 1999). Thus, hierarchical models are assumed to be crossed by pathways whereby life experiences first affect specific levels of the hierarchy and then modify more global elements. The lowest and most specific levels are assumed to be the most sensitive to environmental influences and thus the least stable. The highest and most general level, on the other hand, is the most stable and least sensitive to specific experiences. In contrast, other psychologists suggested that self-esteem mainly derives from affective processes (Brown, 1998). This approach is consistent with the evidence that many attitudes are affectively based. According to Brown (1993), "specific beliefs about one's competencies and attributes are considered as consequences rather than antecedents of global self-esteem and are used to buttress and sustain feelings of self-worth" (p. 32). Thus, the apex of the self structure would be the most sensitive to mood variations and the most stable level. Although self-concept as a hierarchically organized construct is now well established, the processes that would explain the changes in self-esteem still need to be identified.

These opposite theoretical conceptualizations of self-concept (i.e., cognitive vs. affective) led to several hypotheses about the causal influences among the elements of the hierarchical structure. Based on the assumption of predominantly cognitive functioning, the *bottom-up*

hypothesis suggests that influences diffuse from the lowest elements at the base of the self structure to higher-level dimensions (Fox, 1990; Harter, 1999; Sonstroem *et al.*, 1994). For example, high satisfaction with a given physical strength task reinforces the feeling of competence in the corresponding sub-domain, then enhances physical self-worth and finally global self-esteem. According to self-enhancement theory (Sonstroem *et al.*, 1994), physical self-efficacy is the primary cognitive link between physical measures and higher-order psychological constructs. This suggests that behavioral outcomes influence self-efficacy beliefs, which in turn contribute to determine more global constructs of competence and self-esteem. The *bottom-up* hypothesis has been widely tested empirically and currently seems to be the most agreed upon. Conversely, the *top-down* hypothesis, which assumes the predominance of affective functioning, suggests that causal flow is directed from the apex of the structure to the lower-level dimensions (Brown, 1993; 1998). In other words, global self-esteem is massively submitted to emotions and mood change (Greenier *et al.*, 1999) and a sudden depreciation due to negative emotions, for example, would irradiate to subjacent domains, such as the physical domain, and then modify the corresponding sub-domains. However, this perspective is fairly speculative and lacks empirical support and refinement.

Bottom-up and *top-down* hypotheses are not utterly opposed in that they both acknowledge that global self-esteem and self-evaluations in specific domains are related, with only the direction of causal flow being inverted. Some authors have considered the possibility of simultaneous cognitive and affective routes of causal flow and suggested a third hypothesis, the *reciprocal* (Marsh & Yeung, 1998) or bi-directional (Feist, Bodner, Jacobs, Miles, & Tan, 1995) model. According to this hypothesis, diffusion processes follow both directions. Finally, Marsh and Yeung (1998) and Kowalski and his colleagues (Kowalski, Crocker, Kowalski, Chad, & Humbert, 2003) used structural equation modeling to test the direction of causal flow in the physical self structure based on two assessment moments separated by a period of one year. They used respectively the Physical Self Description Questionnaire and the Physical Self Perception Profile and concluded in favor of a fourth hypothesis of causal flow: the *horizontal effects* model. This model emphasizes the stability of each component over time and suggests that the current value for a perceived dimension depends mainly on its previous value. This perspective offers weak support to the hierarchical conception of the self-structure because it assumes the independent functioning of the structural elements.

Despite the interesting work of Marsh and Yeung (1998) and Kowalski *et al.* (2003), little has been established regarding the direction of causal flow in the physical domain. Heuristic speculations about the *bottom-up* hypothesis introduced by Fox (1990) or the *reciprocal* influences remain to be empirically supported. Two main objections may be addressed to these studies. First, two assessment moments are not sufficient to capture changes between dimensions. Although researchers have generally insisted on the need for longitudinal data collection to test causal flow hypotheses (Amorose, 2001; Marsh & Yeung, 1998), few attempts have been made to fully analyze the time-evolutionary properties of the hierarchical structure. Instead, most studies have focused on the contextual determinants of self-esteem fluctuations and have borrowed static rather than dynamic methodological approaches. The second objection to previous attempts to demonstrate causal influence is that the approaches have been nomothetic rather than idiographic.

Intra-individual studies need to be highly pertinent to provide a formal framework for identifying causal flow in the physical self structure. The hierarchical model of physical self and global self-esteem developed by Fox and Corbin (1989) can be considered as such a framework: a complex system subjected to several constraints over time that produces the same causal flow (Harter, 1999; Ninot *et al.*, 2001; Nowak, Vallacher, Tesser, & Borkowski, 2000; Robins *et al.*, 2001). For example, the *bottom-up* hypothesis would be supported if, for each individual, a systematic change in the physical strength sub-domain altered the physical self-worth level after a time delay, and if this change was in turn followed by a delayed change in global self-esteem.

Intra-individual studies are needed to verify whether which causal flows underlie the functioning of the self system over time. It is assumed that the causal flow direction would correspond to specific patterns in the results emerging from time series analyses. From now, our studies considered the collected series separately, and neglected to examine their interactions. The assessed dimensions are conceived as the interconnected components of a hierarchically organized system, but the way by which one dimension could influence its neighbors in the model remains an open question.

Relation with other variables

Accuracy between abilities and perceived competence is a good predictor of mental health (Harter, 1999), especially for mood and dynamism. Nevertheless, few studies propose intra-individual protocol measuring both biological and psychological variables. Authors explain this situation using psychological arguments such as inexperience, lack of expertise, positive cognitive biases, auto-handicap strategies, overgeneralization, modesty or social desirability, and methodological arguments such as time limited protocols (see 1.2) or the fact to studying too global dimensions (Buckworth & Dishman, 2002).

For example, the accuracy between endurance variables and perceived physical dimensions should be an important indicator of training improvement. Endurance athletes hope to become professional and are therefore intensely focused on their daily physical condition. The accurate perception serves to motivate training, support their life projects, and improve their well-being (Sonstroem *et al.*, 1994).

Applications

On practical plan, psychological survey of a participant can be useful during certain life phases such as reeducation, learning session and behavioral change attempt. Personality questionnaires, enclosing subjects in restrictive categories or level, are susceptible to obstruct future psychological interventions. The repeated completion of brief tools and the comprehension of individual dynamics will permit to improve participation to any psychological intervention.

Determination of MA (0,1,1) coefficient or, in some case, of nature of dynamics, indicates the manner of using *adaptation* and *preservation* processes. With a certain paradox, *trait* or *state* functioning will appear respectively too rigid or too environment dependant to cope with efficacy to ecological constraints. From a psychopathological viewpoint, researchers will observe dynamical diseases (McKey et Milton, 1995) due to self-perception troubles.

If we worked massively on ecological context, observation of specific impacts on self-esteem using experimental design or simulation protocols will be very interesting. For example, we can study the consequences of an event on relaxation time, causal flow and/or change in the hierarchical structure.

In contrast to personality psychology, dynamical social psychology tries to understand recent behavior. Auto-correlation, omnipresence of MA (0,1,1) model and probable non-linear functioning open a new comprehension of human complexity for less than two years. This perspective opens great perspective to understand life transition periods such as disease, damage, mourning, retirement, or specific moments such as momentum, flow…

Several nomothetic studies failed to produce accurate prevision of exacerbations in chronic disease patients or optimal performance in athletes. Self-esteem conceived as a complex system submitted to random constraints can not be predicted over a long period. Conversely, prevision over a short term period with intra-individual survey can be possible with an associated probability coefficient. For example, ARIMA procedures are dedicated to obtain this coefficient.

The computer version of brief questionnaires can be useful in education, prevention or reeducation situations. Items (objective and/or subjective) can be added to observe specific and/or individualized symptoms. The automatic transcription to PDA can enhance care motivation in chronic disease patients. The development of Internet transfer data can inform clinician of compliance and health behaviors.

Individual curves offer opportunities to researcher and clinician to exchange with the user of a brief instrument. The comments of these curves will have determinant sense. The curves are support for interview, a kind of "relationship mediator". It is an occasion to point out changes, perturbations, oscillations, cyclic events… Verbalize within a curve traducing our own history is an opportunity to take distance, to observe recursive changes, and eventually understand differently. This strategy can have therapeutic virtues within the work of a psychologist. This can help the person to relive differently events. For a chronic disease patient, the visualization of curve can help to change behaviors and to detect causes producing symptoms exacerbations.

CONCLUSION

Nowak and Vallacher (1998) have opened social psychology to dynamical approach. Nevertheless, few authors from now have prolonged analogies or computer simulations (such as cellular automata) with empirical or experimental protocols. To the past, other authors, convinced of heuristic power of intra-individual survey, were stay on hypothesis phase (Mischel & Shoda, 1998).

The difficulties of intra-individual protocols, the lack of brief instruments, the need to use time series analyses rarely at the program of psychological studies and skepticism of review's expert with innovation were constraints to the advent of empirical or experimental proofs. Now, all theoretical methodological elements are ready to study the functioning of social psychology variables in a field quasi-unexplored.

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