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Integrating personality, daily life events and emotion: Role of anxiety and positive affect in emotion regulation dynamics

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ABSTRACT

We investigated the roles of anxiety and positive affect in emotion regulation, looking simultaneously at personality, daily life events, and affects. We hypothesized that individual differences in the temporal dynamics of affective experience related to trait anxiety would manifest themselves both in affective responsiveness to life events and in homeostatic regulatory forces. Data were collected from 49 adults, who rated their affective state three times a day over a 40-day period. Data were analyzed using a dynamical system model and graphical representations in the form of vector fields. Results showed that anxiety chiefly interacted with home base (attractor) positions as a function of life events. It also influenced the shape of positive affectivity trajectories in response to negative events.

1. Introduction

A fundamental characteristic of emotions and affective experiences is that they vary over time. Our lives are characterized by affective ups and downs, changes and fluctuations following the ebb and flow of daily life. Understanding the nature of the temporal dynamics of affect and emotion, and the processes that underpin them, as well as individual differences in the patterns and regularities characterizing affect dynamics (Kuppens, Oravecz, & Tuerlinckx, 2010) remains one of the most important challenges in the study of emotion (Scherer, 2009).

It is important to study the dynamics of emotional fluctuations, as this allows us to predict observable behaviors more accurately (e.g., Eid & Langeheine, 1999; Ghisletta, Nesselroade, & Featherman, 2002; Nesselroade, 1988, 2001). A better understanding of the mechanisms that underpin emotion regulation could help us gain a clearer idea of individual trajectories and of the long-term impact of these mechanisms on psychological health and well-being (Dodge & Garber, 1991). Given that their impairment can account for various personality disorders, including depression and anxiety, they constitute key factors in numerous psychiatric diagnoses (Murray, Allen, Trinder, & Burgess, 2002; Russell, Moskowitz, Zuroff, Sookman, & Paris, 2007).

There has been a growing interest in the dynamics of emotion regulation processes (John & Gross, 2007; Vansteelandt, Van Mechelen, & Nezlek, 2005) and more and more researchers are now starting to examine the patterns and regularities that drive the dynamics of affect (Kuppens et al., 2010). The main aim of the present study was to undertake the simultaneous investigation of affect, personality and daily life events (Nezlek & Kuppens, 2008), and more specifically to study the role of anxiety in variations in positive and negative affect in reaction to events, within the framework of a model of affect dynamics (DynAffect; Kuppens et al., 2010). This model formalizes three processes involved in affective fluctuations and seems to offer a heuristic conceptual framework for exploring individual differences. We refer to this framework throughout our paper. After describing the DynAffect model (Kuppens et al., 2010) in some detail, we tackle the role of personality in affective fluctuations, focusing on trait anxiety and its links with the perception of daily life events. We then attempt to pinpoint the role of positive affect in emotional dynamics.

1.1. A dynamical system model for the study of individual differences in affective fluctuations

The DynAffect model developed by Kuppens et al. (2010) treats the affect system as an open, dynamic system featuring three main sources of interindividual variations: the coordinates of the home base – a baseline attractor state or benchmark –, the range of

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affective fluctuations around this home base, and the strength of the system's homeostatic attraction force, which curbs these fluctuations brought about by internal or external processes.

This model considers affect in a two-dimensional space, with valence along the *x*-axis and arousal along the *y*-axis. The home base constitutes an equilibrium point in this two-dimensional system, serving as a specific attractor for each individual, around which the latter's affective state fluctuates. Particularly wide affective fluctuations constitute discomfort zones, motivating the individual to engage regulation processes in order to restore equilibrium and return to the home base (Russell, 2003). The basic idea, therefore, is that our affective state fluctuates around an equilibrium point, which serves as a baseline for the affective system, reflecting its expected state given the characteristics of its environment in a given period. It reflects the average emotional experience of a person in a given period. It can also be viewed as the point where the affective state would stabilize itself in a steady and homogeneous environment. In the DynAffect model, the home base position is essentially an individual characteristic. In our view, the home base position is linked to the appraisal that an individual makes of their environment. It is thus influenced by both individual and environmental characteristics.

If the first process is the affective home base, the second process is variability, referring to affective changes and fluctuations. Being an open system, our affective state is subject to dynamic-stochastic variability (Russell, 2003, 2009) resulting from the many internal and external events that influence our core affect at any given time. The extent of these variations depends on the individual. Some of us experience important emotional changes, react more strongly to the event or encounter more striking events, while others experience a life more stable emotionally.

The third process is the force exerted by the attractor, or home base. If, after a perturbation, the affective state of a person is far away from its current home base, this state will move gradually toward the home base driven by the attraction force of this home base. One can imagine this attraction, by the force exerted by a spring attached to the home base. The spring gradually returns to its initial state after being stretched, suggesting regulation processes. The intensity of this force depends on the distance between the current emotional state and the home base. The further the affective state moves away from the home base, the greater the attraction force. Whenever events open up too great a gap, this self-regulation process undertakes to redirect affect toward the system's equilibrium point. Its purpose is thus to prevent the system from reaching extreme values and, by so doing, reduce the affective fluctuations that disturb the individual's equilibrium and, by extension, his or her psychological wellbeing. The intensity of the attraction also depends on the thickness of the spring which could vary depending on the subject and relies on dispositional characteristics. A person with a hight attraction strength returns more easily to his home base. This model has shown its ability to account for emotional fluctuations in a longitudinal protocol.

The model used in this study basically replicates the framework developed by Kuppens et al. (2010), albeit with three modifications. The first difference concerns the two axes of affective space. Whereas the DynAffect model relies on the distinction between valence and arousal, we decided to take positive affect (PA) and negative affect (NA) as its two axes. This choice raised the question of the independence or bipolarity of PA and NA, which has been the subject of hot debate in the literature (Russell & Carroll, 1999; Watson & Tellegen, 1999). One of the present study's objectives was to analyze combined changes in PA and NA in reaction to daily life events and, more specifically, the likelihood of asynchrony and uncoupling between PA and NA. This amounted to assuming that there is a degree of leeway in NA–PA bipolarity and a relative independence in certain conditions (Reich, Zautra, & Davis, 2003; Zautra, Affleck, Tennen, Reich, & Davis, 2005). For this reason, we believed it was important to collect PA and NA data separately and to make them the main axes of affective space. This meant that we had to neglect variance linked to arousal to some extent, even though it could well be relevant here (Kuppens, Van Mechelen, Nezlek, Dossche, & Timmermans, 2007). A more comprehensive approach would consist in considering three dimensional affective space (PA, NA and arousal), as Stanley and Meyer (2009) recently suggested, but this would result in a far more complex model and go far beyond the scope of our research.

The second contribution deals with the concept of home base and its relation with life events. We believed that this notion could be extended, by regarding it as the result of environmental factors, as well as individual characteristics. For example, an individual might have a home base in one position corresponding to a welcoming environment characterized by a succession of positive events (e.g., a week's vacation) and in another position corresponding to a hostile environment characterized by overwhelmingly negative life events (period of considerable stress at work). In each case, therefore, the system would stabilize itself or fluctuate around a different equilibrium point with different coordinates. We therefore decided to turn the home base into a continuum, rather than a fixed point – a curve in affective space where each section would correspond to life events of a particular valence. Some of the DynAffect model's variability parameter was therefore represented by this affective "moving target". In order to track this variability, our protocol provided for the recording of daily life events at each observation. The first set of hypotheses we tested therefore concerned shifts in the home base according to daily life events and trait anxiety.

The third contribution was to take eventual coupling effect between PA and NA into account to describe individual trajectories in the affective space. In the present study, PA and NA were assumed to be governed by two distinct but connected entities. This connection could take the shape of a lateral inhibition of one on the other. Empirical results show that changes in PA and NA are negatively correlated when they are studied in dynamics (Vautier, Steyer, Jmel, & Raufaste, 2005) and this correlation is increased when the interval between observations is shorter (Diener, Smith, & Fujita, 1995).

The study of eventual coupling (Zautra et al., 2005) effects between AP and AN also allows to examine the role of positive affects in the regulation of negative emotions, which is a major objective of this research. More particularly, it is assumed that, during the recovery phase after a negative event, the occurrence of PA might contribute to a reduction of NA (Ong, Bergeman, & Bisconti, 2006). Some of us may be able to use PA in order to curb the increase in NA in the recuperation phase, this idea is detailed in the Section 1.3.

The coupling is not always complete between PA and NA. The coexistence of positive and negative affects has been shown in literature (Cacioppo, Larsen, Smith, & Berntson, 2004). The model that we used is flexible enough to highlight the effects of coupling while allowing certain independence between PA and NA and taking into account the coexistence of high levels of PA and NA found in literature (e.g., being happy and sad at the same time). Technically, this kind of coupling effect can be modeled using cross-lagged regression coefficients. The next two sections first relate the role of anxiety in the differences in affect regulation and the role of positive affect in the regulation of negative affect.

1.2. Anxiety, response to daily life events and emotion regulation

The factors involved in emotional fluctuations (subjective assessment of events, biological and environmental factors) are numerous and interconnected, and it is the outcome of this complex combination that determines affective variability over time (Fok, Hui, Bond, Matsumoto, & Yoo, 2008). Whereas the relationship between personality and affective responses has been investigated on many occasions (see, for example, Diener et al., 1995; Larsen & Ketelaar, 1989; Yik & Russell, 2001), the relationship between intraindividual affective variability and personality has rarely been considered (Eid & Diener, 1999). Although the usefulness of studying the individual ∗ situation transaction is underscored in numerous models (Mischel & Shoda, 1998), approaches have tended to focus either on the role of events or on personality, and only rarely on the two together. The aim of the present study was thus to highlight the interaction between personality, daily life events and affective fluctuations. Fluctuation predictors mentioned in the literature include neuroticism and extraversion, anxious and depressive characteristics, self-esteem and coping strategies (e.g. Beck, 1985; Eid & Diener, 1999; Kuppens & Van Mechelen, 2007; Kuppens et al., 2007; Larsen & Ketelaar, 1989). However, we chose to focus on anxiety, as this is the dimension with the most convergent results.

Trait anxiety is one of the most insidious facets of personality when it comes to emotional management, giving rise to poorly adjusted emotion regulation processes (Zelenski & Larsen, 2002). It is defined as a stable characteristic that predisposes individuals to perceive situational information as a threat or potential danger (Beck, 1985) and react by displaying disproportionately intense anxiety, given the degree of objective danger (Spielberger, 1966). It is also characterized by heightened sensitivity to threat stimuli, resulting in an excessive tendency to summon NA (Gray, 1987; Zelenski & Larsen, 1999). Anxious subjects ruminate for longer on negative events (Muris, Roelofs, & Rassin, 2005) and find it hard to put them into perspective (Avila, Parcet, Ortet, & Ibáñez-Ribes, 1999; Corr, Pickering, & Gray, 1995; Gupta & Shukla, 1989; Zinbarg & Mohlman, 1998).

Researchers who have triangulated personality, events and emotions by undertaking multilevel analyses have shown that the occurrence of threatening events is an important factor in the increase of NA, but that personality also plays a non-negligible role in regulating the individual ∗ situation transaction (De Beurs et al., 2005). This type of approach makes it possible to identify the particular relationship that exists between personality, situation and behavior, and to bring discussions about personality into sharper conceptual focus (Mischel & Shoda, 1995). It was within this framework that the present study was conducted. Our first set of hypotheses was that anxiety exerts a major influence on home base position and on the dynamics of emotional trajectories over time, more specifically the force of attraction and its direction. For example, the advent of a negative event leads to the activation of behavioral repertoires at the intraindividual level that may differ according to the level of that person's trait anxiety and therefore generate specific trajectories in affective space. These affective responses may, in turn, have an impact on home base position; the home bases of anxious individuals would be more negative than those of their non-anxious peers. We also probed the influence of PA on the regulation of NA, as set out in the following section.

1.3. The role of positive affect in emotion regulation: the relevance of studying the dynamic interaction between positive and negative affect

An increasing number of studies have highlighted the contribution of PA to affect regulation (Lyubomirsky, King, & Diener, 2005; Tugade, Fredrickson, & Barrett, 2004) and sought to elucidate the role it plays in adaptive behavior in stressful situations (Zautra et al., 2005). More importantly still, as far as we are concerned, these studies have suggested that PA serves to replenish the individual's resources, thereby enabling the latter to recover from negative events (Ong et al., 2006). PA appears to broaden thought-action repertoires and enhance problem-solving (Fredrickson & Branigan, 2005; Isen, Daubman, & Nowicki, 1987). It counterbalances the negative physiological effects of NA (Ong & Allaire, 2005) and promotes the use of suitable coping strategies (Folkman & Moskowitz, 2000). It also facilitates the implementation and management of resources in order to deal with a negative event (Tugade et al., 2004) and allows for more rapid recovery following stressful events (Fredrickson, Tugade, Waugh, & Larkin, 2003; Zautra et al., 2005). Thus, whereas NA is governed by the sympathetic nervous system, which narrows attention in order to direct it toward relatively primal actions (fight or flight), PA offers a means of reducing the automatic activation of the sympathetic nervous system triggered by NA and of broadening attentional capacity, thought and behavioral repertoires (Fredrickson, 2001). Therefore, people with a high level of positive affectivity have easier access to a range of behavioral repertoires that allow them to adjust more successfully to stress (Ryff, Singer, Love, Essex, & Lomranz, 1998; Staudinger, Marsiske, Baltes, Cicchetti, & Cohen, 1995).

Our second set of hypotheses was therefore based on these studies and, more particularly, on the research conducted by Cacioppo et al. (2004) and Zautra, Smith, Affleck, and Tennen (2001), which assumes that the ability to maintain PA and strike a balance between PA and NA reflects a potential for adaptation and flexibility. Bergeman and Wallace (2006) studied the role of PA when faced with a stressful event. Multilevel analyses showed that PA helped to moderate reactions to a given event. Resilient participants with a high level of PA seemed better able to recover when faced with daily life stressors and more efficient in the way they tackled, managed and transformed stressful events.

This point can be translated in our model using the idea of inhibitory coupling effect between PA and NA. The coupling effect can be deleterious just after a negative event when a rising of NA inhibits PA, but it can also have a positive effect if a rebound of PA can curb the increase of NA. It seems that more resilient people are able to use this last property more efficiently. We expected that for these people, a stronger coupling effect would appear. The intensity of the coupling could then vary among subjects as a function of trait anxiety.

Our aim was to demonstrate how far interactions between personality dispositions, studied from the angle of trait anxiety, and daily life events influence home base position and homeostatic forces (attractor strength), by investigating the role of PA in the regulation process. To this end, we developed four specific hypotheses, two concerning the position of the home base and two concerning its attraction strength and the coupling of PA and NA. Our first hypothesis was that daily life events are capable of modifying the coordinates of individual home bases. As such, we expected individual differences to be expressed in the shape of several different home bases corresponding to events of different valence. Our second hypothesis concerned the effect of trait anxiety on home base position, predicting that the home bases of the most anxious participants would be more negative on the whole, with greater reactivity to negative events. Our third hypothesis was that the less anxious individuals should exhibit stronger attraction strength. A person with a hight attraction strength returns more easily to his home base reflecting more efficient emotion regulation mechanisms (Kuppens et al., 2010). Our fourth and final hypothesis concerned the existence of a partial and negative coupling of PA and NA. We assumed that the ability to feel PA could allow, in addition to the attraction strength, to regulate negative emotions. This effect could be of different intensity depending on the trait anxiety.

2. Method

2.1. Participants

Psychology students made up one third of our sample, while the remaining two thirds comprised unselected adults from the first author's workplace. There were 61 volunteers at the outset, but 12 of them dropped out due to the complexity of the protocol. The cohort was thus reduced to 49 participants (19 men and 30 women;

19–77 years old, $M = 36$, $SD = 12$). Twenty of them lived alone (unmarried, widowed or divorced) and 29 with a partner. Their levels of education ranged from no high-school diploma to 3 years of higher education. More than 50% of the population had completed at least 1 year of higher education. Twenty-nine participants had an occupation, 12 were students and eight were either retired, unemployed or without an occupation. The participants were not remunerated, although they were offered a personalized debriefing of their results.

2.2. Material

2.2.1. Anxiety assessment

The State-Trait Anxiety Inventory (STAI-trait; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) was used to measure trait anxiety, which is the general propensity to be anxious. Participants rated self-descriptive statements (20 items) on a four-point Likert-like scale, ranging from 1 = "does not describe me at all" to 4 = "accurately describes me".

2.2.2. Event assessment

The assessment of daily life events was based on the seven areas of the typology used in the life events questionnaire devised by Sarason, Johnson, and Siegel (1978): affective (love, friendship, and interpersonal relations), material and financial, separation or death, health, work, habits and leisure, and crime and legal matters. Participants had to rate the events that had happened to them in each area since the last assessment on a six-point scale ranging from "extremely negative impact" (coded −3) to "extremely positive impact" (coded +3). They were given the following instructions: "This list contains a number of areas in which events can sometimes bring about emotional changes. Please indicate whether you have experienced events in any of these areas since the last assessment. Indicate whether these events had a positive or a negative impact on your emotions or moods when they occurred, and the type and extent of the impact these events had on you. If you have experienced several events in a given area, select the one that had the greatest impact on your emotions at the time." If no event was reported in a particular area, the variable was coded 0. Within each of the three daily assessments, the values for the different areas were aggregated to provide a single variable. This variable was then divided in two variables: negative events (NEs), encompassing negative valence events, and positive events (PEs), encompassing positive valence events. The values of these two variables were exclusive: in other words, when one of them was different from zero the other was necessarily equal to zero. The rationale behind this choice is described in greater detail in Section 2.4.

2.2.3. Affect assessment

Affect was assessed using 16 adjectives rated on a five-point scale, ranging from 1 = "not felt at all" to 5 = "strongly felt". The instructions were as follows: "The following list contains words describing different feelings or emotions. Read each word carefully and indicate the degree to which you have experienced this type of emotion since the last assessment. Please reply as honestly as possible, without missing out any of the words." Based on a circumplex approach (De Raad & Kokkonen, 2000), this scale provided a means of assessing affect in terms not only of valence (PA or NA) but also of arousal, although we concentrated on the former in the present study. Eight of the adjectives represented NA (nervous, angry, irritated, annoyed, bored, gloomy, sad, and worried), and eight of the adjectives represented PA (surprised, cheerful, excited, delighted, serene, calm, quiet, and still). Responses to the eight negative valence items were summed to obtain a negative affectivity score, and responses to the positive valence items were summed to obtain a positive affectivity score.

2.3. Procedure

We chose to adopt a longitudinal approach because emotion regulation processes are not dependent solely on situations but also rely on genuine interactions between the individual and his or her environment (Diamond & Aspinwall, 2003). We implemented an experience-sampling method (ESM)-type protocol, with the result that the study took place in two phases. In the first phase, participants were asked to assess their anxiety by filling out the STAI. The longitudinal study, constituting the second phase, started a week later. Participants were asked to make three assessments each day (late morning, between 11 am and 2 pm, late afternoon, between 5 and 7 pm, and just before going to bed) over a 40-day period, indicating the types of events they had encountered since the previous assessment and describing their affective experience based on the 16 affective items. They were each given a comprehensive logbook with a page for each of the three daily assessments (affect and daily life events) for the entire 40 days. The assessment times were agreed on at the outset with each individual participant, according to his or her lifestyle (times at which they got up, had their meals and went to bed), which explains the broad time ranges. When it was time for them to perform one of these assessments, participants were beeped on their mobile phones.

2.4. Data analyses and model specification

In the present study, PA and NA were assumed to be governed by two distinct but connected entities a connection that can be expressed as the relationship between PA (or NA) at time t and both PA and NA at time $t-1$. This relationship formed the basis of the bivariate difference score (BDS; Hamagami & McArdle, 2007; McArdle & Hamagami, 2001) model we used here and it was formalized as two separate general regression equations, where i represented participants ($i = 1, \ldots, N$) and t indicated the point of measurement ($t = 1, \ldots, T$):

$$PA_{it} = \beta_{P0} + \beta_{P1}PA_{it-1} + \beta_{P2}NA_{it-1} + e_{Pit} \tag{1}$$

$$NA_{it} = \beta_{N0} + \beta_{N1}NA_{it-1} + \beta_{N2}PA_{it-1} + e_{Nit} \tag{2}$$

The BDS allowed us to calculate a participant's affective state at time t as a point in two-dimensional space, with PA and NA levels as coordinates. This part of the model essentially stated that changes within this two-dimensional affective space between time $t-1$ and time t (represented by a vector or arrow) depended solely on the start point. The subsequent speed and direction of that point representing affective state were defined by our first two equations. Three kinds of parameters appeared in the equation: two intercepts (β_{P0} and β_{N0}), two autoregressive coefficients (β_{P1} and β_{N1}) and tow cross-lagged regression (β_{P2} and β_{N2}). Within the conceptual framework of the DynAffect model (Kuppens et al., 2010), which states that one of the processes underpinning the system is attractor strength, these two equations could be said to define both the attractor (coordinates of the home base) and its strength. The values μ_P and μ_N, representing the attractor's coordinates on the x-axis (PA) and y-axis (NA), were determined by the model's parameters as follows (cf. Appendix):

$$\mu_P = \frac{(1-\beta_{N1})\beta_{P0} + \beta_{P2}\beta_{N0}}{(1-\beta_{P1})(1-\beta_{N1}) - \beta_{P2}\beta_{N2}} \tag{3}$$

$$\mu_N = \frac{(1-\beta_{P1})\beta_{N0} + \beta_{N2}\beta_{P0}}{(1-\beta_{P1})(1-\beta_{N1}) - \beta_{P2}\beta_{N2}} \tag{4}$$

In the DynAffect model, attractor strength is defined as the coefficient linking the *speed* of change in affect level to the *distance* between the current affect level and the home base. When this idea was expressed in our discrete-time model, we obtained the following transition equations (cf. Appendix):

$$PA_{it} - PA_{it-1} = (\beta_{P1} - 1)(PA_{it-1} - \mu_p) + \beta_{P2}(NA_{it-1} - \mu_N) \quad (5)$$

$$NA_{it} - NA_{it-1} = (\beta_{N1} - 1)(NA_{it-1} - \mu_N) + \beta_{N2}(PA_{it-1} - \mu_P) \quad (6)$$

Each dimension of affective space therefore had an attractor strength parameter and a coupling parameter. The magnitude of change and its direction along one of the axes depended on the distance between the current affective state and the home base on both that axis and the other axis. This parametrization allowed us to model coupling effect between PA and NA.

Thus far, the model worked as a closed unit and did not react to environmental stimuli. However, as we believed that daily life events could explain the changes occurring between time $t-1$ and time t, they needed to be added to the model. Events had been coded as two distinct variables (PE and NE), both ranging from 0 to 3. The rationale for this choice was that changes induced by PEs and NEs are not necessarily colinear: whereas an NE is assumed to increase NA, PA may remain unchanged if it is already at a low level. Similarly, a PE may only change PA. The impact of daily life events on the position of the home bases was introduced into the model by including them in the intercepts of the general regression equations.

$$\beta_{P0} = \gamma_{P00} + \gamma_{P01}NE_{it} + \gamma_{P02}PE_{it}$$

$$\beta_{N0} = \gamma_{N00} + \gamma_{N01}NE_{it} + \gamma_{N02}PE_{it}$$

Although the introduction of daily life events did not modify attractor strength, it did affect the position of the home base. According to this model, an individual's affective state could become stabilized at different locations in affective space, according to whether he or she was immersed in a welcoming environment (e.g., a week's vacation) or a more hostile one (e.g., a period of stress at work). Unlike DynAffect, our model did not contain a variability parameter explicitly defining fluctuations around the home base. Even so, this variability was taken into account, to some extent at least, in the shape of variations triggered by the daily life events recorded by our participants. Readers who are familiar with the notation used in the multilevel model literature may be surprised by the absence of random effects in these two equations. However, this absence can be explained by the use of the generalized estimating equations (GEE) method, whose advantages are set out in greater detail below.

Individual differences in personality in the form of trait anxiety may exert an influence at several levels. Anxiety may: (a) influence home base position in general, (b) modify sensitivity to life events and hence the effect these life events have on home base position, and (c) exert an influence on internal attractor strength, that is, on the relationship between affect at time t and affect at time $t-1$. The first two effects could be tested by adding anxiety to the model at the level of the intercept, in the shape of a main effect for (a) and an interaction with daily life events for (b). The third effect (c) required anxiety to be introduced at the level of the parameters governing the transition equations. As anxiety (ANX) was regarded as a trait, it was indexed by participant, not time.

$$\begin{aligned}\beta_{P0} = {} & \gamma_{P00} + \gamma_{P01}NE_{it} + \gamma_{P02}PE_{it} + \gamma_{P03}ANX_i + \gamma_{P04}ANX_iNE_{it} \\ & + \gamma_{P05}ANX_iPE_{it}\end{aligned}$$

$$\begin{aligned}\beta_{N0} = {} & \gamma_{N00} + \gamma_{N01}NE_{it} + \gamma_{N02}PE_{it} + \gamma_{N03}ANX_i + \gamma_{N04}ANX_iNE_{it} \\ & + \gamma_{N05}ANX_iPE_{it}\end{aligned}$$

$$\beta_{P1} = \gamma_{P10} + \gamma_{P11}ANX_i$$

$$\beta_{N1} = \gamma_{N10} + \gamma_{N11}ANX_i$$

$$\beta_{P2} = \gamma_{P20} + \gamma_{P21}ANX_i$$

$$\beta_{N2} = \gamma_{N20} + \gamma_{N21}ANX_i$$

When we developed the general regression Eqs. (1) and (2), we obtained the following detailed regression equations, each containing four interaction terms. Testing the interaction effects amounted to testing the effects of four new variables containing the result of the multiplication of anxiety by the other four predictors.

$$\begin{aligned}PA_{it} = {} & \gamma_{P00} + \gamma_{P10}PA_{it-1} + \gamma_{P20}NA_{it-1} + \gamma_{P01}NE_{it} + \gamma_{P02}PE_{it} \\ & + \gamma_{P03}ANX_i + \gamma_{P21}NA_{it-1}ANX_i + \gamma_{P11}PA_{it-1}ANX_i \\ & + \gamma_{P04}NE_{it}ANX_i + \gamma_{P05}PE_{it}ANX_i + e_{Pit} \quad (7)\end{aligned}$$

$$\begin{aligned}NA_{it} = {} & \gamma_{N00} + \gamma_{N20}PA_{it-1} + \gamma_{N10}NA_{it-1} + \gamma_{N01}NE_{it} + \gamma_{N02}PE_{it} \\ & + \gamma_{N03}ANX_i + \gamma_{N11}NA_{it-1}ANX_i + \gamma_{N21}PA_{it-1}ANX_i \\ & + \gamma_{N04}NE_{it}ANX_i + \gamma_{N05}PE_{it}ANX_i + e_{Nit} \quad (8)\end{aligned}$$

Several methodologies have been put forward for fitting this type of model. Originally, latent difference score models were fitted using structural equation modeling (McArdle & Hamagami, 2001). The linear mixed-effects model, also known as the multilevel or random effects model, is often used to model intraindividual variability (Nezlek & Kuppens, 2008) and could have been used for this purpose here (Maxwell & Boker, 2007). In the present study, however, we decided to adopt a different parameter estimation method – the GEE (Liang & Zeger, 1986; Zeger, Liang & Albert, 1988). This extension of the general linear model is specifically adapted to longitudinal data, where several participants are assessed on several occasions. Unlike the mixed-effects model, local dependencies between observations of a given participant are taken into account not by assessing random effects but by allowing for correlated residuals through a "working correlation matrix". In the mixed-effects model, the number of parameters to be estimated can quickly rise with the number of random effects (the whole variance–covariance matrix of the random effects is estimated), which can lead to a convergence problem when there is a large number of random effects. This difficulty is avoided in GEE models, as the size of the working correlation matrix is not determined by the number of explanatory variables. The cost of this simplification is that instead of providing estimates for individual parameters, GEE models simply give estimates of mean effects at the group level and their unbiased standard error. This was not a problem for us, as the approach we had adopted did not require us to extract individual parameters in order to link them with personality variables at a later stage. Instead, the personality variable we were using was introduced directly into the model.

As we have seen, all the coefficients were involved in determining the coordinates of each home base, making it difficult to interpret each individual parameter taken separately. Taking our cue from research on dynamical systems (Boker & McArdle, 1995), we therefore decided to generate graphical representations of the system's dynamics in order to visualize variations in reaction to daily life events as a function of anxiety. This procedure was entirely congruent with the DynAffect model developed by Kuppens et al. (2010). According to our model, the nature of these variations would depend on the affective state's start point in space, the type of event and the participant's personality. The graphical representations were generated using the values of the explanatory variables predicted by the model. The calculation of these predicted values was based on the same principle as in a classic multiple regression and involved making precise estimates of the regression coefficients. In this context, the GEE method again proved more suitable than a mixed-effects model, as the latter yields less accurate coefficient estimates when the application conditions are not met, in this case the assumption of independence between explanatory variables and random effects (Gardiner, Luo, & Roman, 2009).

The model was fitted to the data using two separate GEE models, and the dependent variable was either PA or NA. The explanatory variables were exactly the same in both models. We used the normal distribution with a linear link function and an independent working correlation structure. The latter allowed us to obtain unbiased estimates of standard deviations (Pan & Connett, 2002) and the probabilities associated with the parameters, and efficiently calculate the predictions required for the graphical representations. Although GEE models do not have classic measures of goodness of fit, such as Akaike's information criterion (AIC; Akaike, 1974), R^2 can nonetheless be computed, as the models' predictions can be calculated.

3. Results

3.1. Descriptive statistics

Table 1 sets out the descriptive statistics for the five variables used in the model. The variables relating to affect had both a theoretical and an observed minimum value of 8 and a maximum value of 40. The mean score for PA, based on the entire set of observations, was 19.9 (SD = 5.56), but the mean score for NA was somewhat lower (M = 13.17, SD = 5.8). Cronbach's alpha was .89 for NA and .84 for PA. As there were very few observations of three negative events, the model's estimates for this level of event should be interpreted with caution. The sample mean score for the anxiety variable was 41.37 (SD = 7.3), with a Cronbach's alpha of .81. The values chosen for the graphical representations (30, 40 and 50) represented low ($z = -1.6$), medium ($z = -0.2$) and high ($z = 1.2$) levels of anxiety.

3.2. Overview of the model's results

In this section, we begin by describing the model we developed and attempting to understand its overall meaning, presenting the data in graphical representations which make it easier to grasp the notions of home base, attractor strength and coupling effect. We then interpret the model's different parameters, focusing first on home bases, as a function of anxiety and type of event, then on attractor strength and finally on the coupling effect between PA and NA.

The model's parameter estimates are set out in Table 2 for PA and NA. Overall, the model accounted for a relatively large proportion of the variance for both PA (R^2 = .534) and NA (R^2 = .571). The parameter estimates were used to generate a series of graphical representations in order to depict event- and personality-related variations in affect in the form of vectors (arrows) in a two-dimensional space, with PA along the x-axis and NA along the y-axis. This approach yielded vector fields (Boker & McArdle, 1995). Ours was a discrete-time model, in which the system's state at time t depended on its state at time $t-1$, as well as on anxiety and on daily life events. The estimated parameters could be used to predict the system's state as a function of given predictor values, just as one can with multiple regression. The first two graphical representations (Fig. 1) describe the system dynamics according to the type of event encountered, a negative event in this case (NE = 2), and the level of anxiety. The panel for low-anxiety participants (STAI at 30) is on the left, and the panel for high-anxiety participants (STAI at 50) on the right. The arrow's start point is the state of the system at time t and its end point the position predicted by the model at $t+1$. Each circle can be interpreted as a possible emotional state of a participant as if they were asked to rate their level of PA and NA at a randomly chosen day. The end point of the arrow is the predicted emotional state of this subject a few hours later given that they encounter a strong negative event between the two moments. All these arrows form a vector field that gives an overview of the results. The bivariate distribution of PA and NA across the observations is indicated by the intensity of the gray shading in this Fig. 1 that represent the density[1] of the observations made by the entire sample in terms of PA and NA. This gray zone has a distinctly triangular form. None of the arrows originate from the upper right-hand sections of either of these fields, as these zones do not contain any actual observations.

The arrows are of varying length and direction, depending on the system's initial position, as specified in the model. A point of convergence can be clearly seen in both vector fields. This point corresponds to the home base where the system would become stable were it to undergo a series of NEs of the same intensity. A long arrow indicates that a fast change is expected and directly reflects a strong attraction force toward the home base. The longer arrows appear far from the home base and they become smaller as the system approaches his equilibrium point.

Table 1
Descriptive statistics.

	Mean	SD	Minimum	Maximum	Cronbach's alpha
Individual level n = 49					
Anxiety (STAI)	41.37	7.1	25	54	.81
Daily observation level n = 5782					
PA	19.90	5.56	8	40	.84
NA	13.17	5.81	8	40	.89
	Value	0	1	2	3
PEs	Frequency	2907	1090	1205	580
NEs	Frequency	4637	685	349	111

Note: PA (positive affect), NA (negative affect), Pes (positive events), NES (negative events).

Table 2
Estimates of model parameters for positive and negative affect.

	PA				NA		
	Coeff. estimate	Std. coeff.	p		Coeff. est.	Std. coeff.	p
Main influence: home bases ($\beta_{P/N0}$)							
γ_{P00}	8.32	.00	.96	γ_{N00}	−.1	.00	.95
γ_{P01} **NE**	−5.17	−.22	<.01	γ_{N01} **NE**	6.54	.47	<.01
γ_{P02} **PE**	1.7	.36	<.01	γ_{N02} **PE**	.81	−.08	<.01
γ_{P03} **ANX**	−.02	−.16	<.01	γ_{N03} **ANX**	.07	.09	<.01
γ_{P04} **NE:ANX**	.08	.07	<.01	γ_{N04} **NE:ANX**	−.06	−.05	.12
γ_{P05} **PE:ANX**	.006	.01	.77	γ_{N05} **PE:ANX**	−.03	−.04	<.05
Main influence: attractor strength ($\beta_{P/N1}$), autoregressive coefficients							
γ_{P10} $\mathbf{PA_{t-1}}$	.54	.48	<.01	γ_{N10} $\mathbf{NA^{t-1}}$	.35	.51	<.01
γ_{P11} $\mathbf{PA_{t-1}}$**:ANX**	−.001	−.01	.67	γ_{N11} $\mathbf{NA_{t-1}}$**:ANX**	.004	.03	.51
Main influence: coupling effect ($\beta_{P/N2}$), cross−regressions coefficients							
γ_{P20} $\mathbf{NA_{t-1}}$	.45	.13	<.01	γ_{N20} $\mathbf{PA_{t-1}}$	.15	.15	<.01
γ_{P21} $\mathbf{NA_{t-1}}$**:ANX**	−.01	−.06	<.05	γ_{N21} $\mathbf{PA_{t-1}}$**:ANX**	.0002	.001	.94
	R^2 = .534				R^2 = .571		

Note: Standardized coefficients (std. coeff.) were obtained by standardizing all the variables before fitting the model. PA (positive affect), NA (negative affect), PE (positive event), NE (negative event).

[1] Density was obtained using the bivariate binned kernel density estimate (Wand and Jones, 1995) with the bkde2D function of KernSmooth package in R (R Development Core Team, 2007).

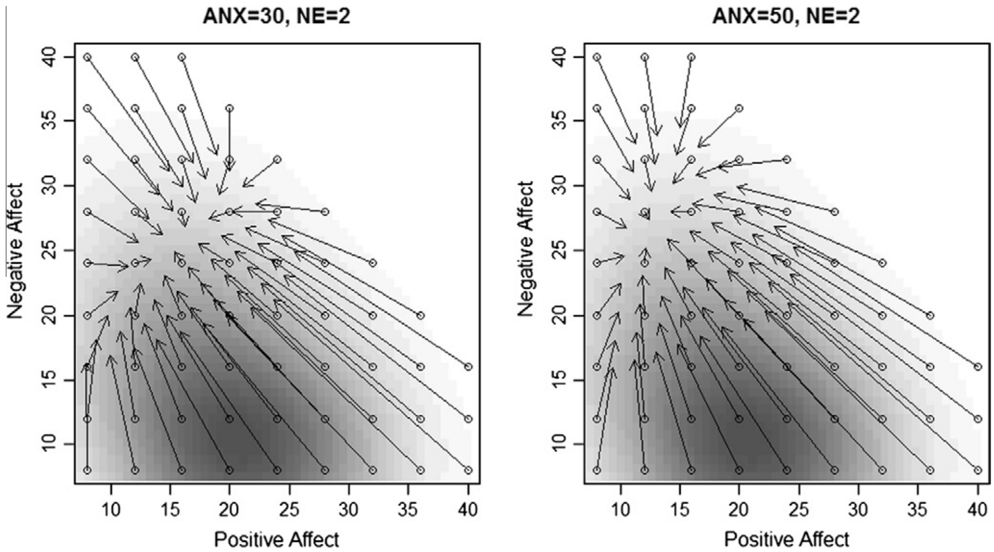

Fig. 1. Vector fields showing variations in PA and NA for a negative event (NE = 2) according to level of anxiety. *Note*. Circles represent the current level of an individual on different occasions in emotional space at time t and arrows represent position at time $t + 1$, as predicted by the model for an NE (NE = 2) occurring at time t. The left-hand panel shows predicted variations for low-anxiety participants (ANX = 30) and the right-hand panel predicted variations for high-anxiety participants (ANX = 50).

Most of these arrows are pointing in the direction of a diagonal downward reflecting a negative correlation between changes in PA and NA and thus coupling effects. We can also see that some of the arrows do not point directly to the home base. The trajectory of a point leaving the most darkly shaded zone in the direction of the home base is not totally straight, probably reflecting interactions between coupling effects and attraction strength of the home bases. This point will be analyzed extensively later. These three elements (home base, attractor strength and coupling effect) constitute the model's key characteristics. They can vary according to the level of trait anxiety and the nature of the events. A descriptive comparison of the vector fields obtained for low (STAI = 30) and high (STAI = 50) anxiety levels suggest several such variations that are investigated in greater detail below.

Table 2 presents the results of fitting the model's two general regression equations to the data. It sets out the coefficient estimates, the standardized coefficients and the probabilities associated with the latter. The standardized coefficients were obtained by standardizing all the variables before fitting the model. This enabled us to reduce any effects of colinearity between main effects and interactions, and obtain more accurate probabilities. In order to link the estimated parameters to the graphical representations, we needed to identify the contributions of each parameter to the three points of interest, namely the coordinates of the home bases, attractor strength and coupling effect between PA and NA. As Eqs. (3) and (4) show, these contributions were closely intertwined, as all the coefficients helped to determine the home bases coordinates. However, while some of them had just a partial influence on home base position, others were also exclusively responsible for attraction strength or coupling (Eqs. (5) and (6)). We were therefore able to pinpoint the main influence exerted by each parameter in order to make it easier to interpret, which is what we did in Table 2. In the following section, we analyze the effects of daily life events and anxiety on home base position. We then turn our attention to attractor strength and coupling of PA and NA.

3.3. Home bases as a function of anxiety and daily life events

Six parameters exerted an influence solely on home base position, these being the β_{P0} and β_{N0} general parameters. To make them easier to interpret, Fig. 2 summarizes the vector representations

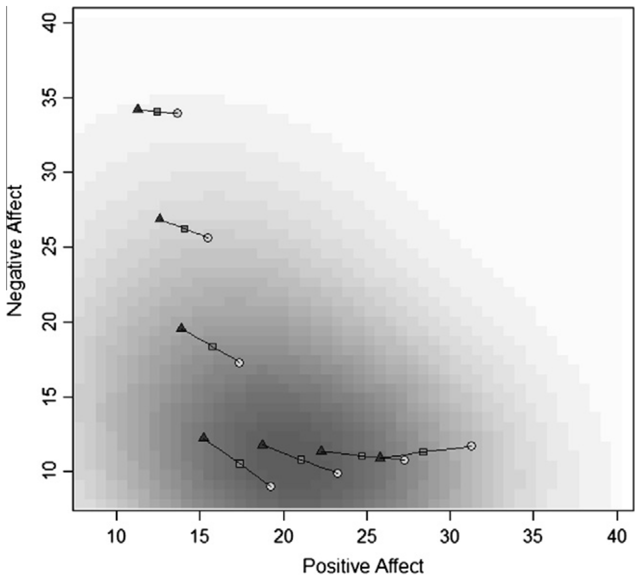

Fig. 2. Home bases for different levels of anxiety and life events. *Note*. The circles represent the home bases for low-anxiety individuals (ANX = 30), the squares those of participants with intermediate anxiety (ANX = 40) and the triangles those of high-anxiety participants (ANX = 50). Each segment corresponds to a different level of event, moving from very negative events (NE = 3) in the top left-hand corner to very positive events (PE = 3) in the bottom right-hand corner. The degree of shading is proportionate to the density of observations across the whole sample.

(similar to Fig. 1) that could be generated for different levels of anxiety and for PEs and NEs ranging from 0 to 3. This figure shows the home bases obtained for three levels of anxiety (ANX = 30, 40 or 50) for all seven levels of events, computed using Eqs. (3) and (4). The home bases corresponding to low-anxiety individuals (ANX = 30) are represented by circles, those of moderate-anxiety individuals (ANX = 40) by squares, and those of high-anxiety individuals (ANX = 50) by triangles. These three home bases were aligned for a given level of event, as the model assumed that anxiety had a linear effect. The four leftmost triangles, which correspond to the home bases for anxious individuals in the face of neutral to negative events (values of NE ranging from 0 to 3), were also aligned. The same pattern can be observed for the circles and squares. These alignments reflect the fact that the model assumed that the effect of the events was also linear. We can see, however, that the alignments corresponding to PEs and NEs are set almost at right angles, confirming the usefulness of dividing the event variable into two separate PE and NE variables.

The two first coefficients shown in Table 2 correspond to what were *y*-intercepts, whose interpretation is not, in itself, particularly informative. NEs made a significant contribution to both PA (γ_{P01} std. = −.22, $p < .01$) and NA (γ_{N01} std. = .47, $p < .01$). The occurrence of an NE therefore reduced the PA level and, to an even greater extent, increased the NA level. PEs had a positive influence on PA (γ_{P02} std. = .36, $p < .01$). The latter also had an effect on NA (γ_{N02} std. = −.08, $p < .01$), although this effect was generally small and dependent upon anxiety levels (γ_{N05} std. = −.04, $p < .05$). Overall, anxiety had a negative effect on home base position on the PA axis (γ_{P03} std. = −.16, $p < .01$) and a positive, but more moderate, effect on NA (γ_{N03} std. = .09, $p < .01$). In the graphical representation, we can see that the circles corresponding to the home bases of low-anxiety participants are indeed located farther to right and generally slighly lower than the triangles representing the home bases of more anxious participants. These results suggest that low-anxiety individuals fluctuated around home bases which, on average, were more positive, but that this effect varied according to the nature of the events. For NEs, the ANX:NE interaction effect was significant on the PA axis (γ_{P04} std. = .07, $p < .01$), meaning that highly negative events closed the gap somewhat between high- and low-anxiety individuals on the PA axis, this difference being most marked in the absence of NEs. We observed a comparable phenomenon for PEs on the NA axis. Anxious individuals' home bases were, on average, slightly more negative (γ_{N03} std. = .09, $p < .01$), but this difference was above all apparent in the absence of PEs, as the latter greatly reduced the difference, as attested by the significant negative interaction between anxiety and PEs (γ_{N05} std. = −.04, $p < .05$). Graphically, the segments for the most positive events are almost horizontal which means that the difference in NA between subjects fades. None of the other effects of the interaction between anxiety and events were significant. Generally speaking, we found that in the case of neutral events, the home bases of the anxious and non-anxious individuals differed for both PA and NA, these differences becoming smaller for extremely positive or negative daily life events.

3.4. Attractor strength and coupling of PA and NA

The β_{P1} and β_{N1} autoregressive parameters linking affect levels at time t to their values at time $t-1$ essentially defined attractor strength as a function of the distance from the home bases, as indicated by Eqs. (5) and (6). We can see that the main effects were significant for both PA (γ_{P10} std. = .48, $p < .01$) and NA (γ_{N10} std. = .51, $p < .01$), and that anxiety did not seem to modulate these effects, as the interaction effects were not significant (γ_{P11} std. = −.01, $p > .05$; γ_{N11} std. = .03, $p > .05$). Attractor strength therefore appeared to remain relatively homogeneous, regardless of the level of trait anxiety.

The β_{P2} and β_{N2} cross-regression parameters linked PA levels at time t to NA levels at $t-1$ and vice versa. At the group level, these parameters made significant contributions in both the PA (γ_{P20} std. = .13, $p < .01$) and NA (γ_{N20} std. = .15, $p < .01$) equations. A significant interaction with anxiety can also be seen in the PA equation (γ_{P21} std. = −.06, $p < .05$).

In the results, both coupling and attraction forces have significant and independent contributions. We must consider that they do not necessarily run in the same direction. The attraction phenomenon directed the affects toward the home bases. The coupling implies the idea that the evolution of NA could be influenced by the evolution of PA and reciprocally. An increase of one would produce a decrease of the other but these influences would be mixed with PA and NA's own regulatory process (i.e. attraction forces). The interaction between these phenomena could lead to the emergence of curved trajectories in the emotional space. Big increases in one dimension were associated with big decreases in the other due to the inhibitory coupling, but when this inhibition had pushed aside the emotional state from its home base on this second dimension, the trajectories was curved toward the home base in its vicinity. Without coupling effect, the trajectories would always point to the home bases directly.

The equation used was very similar to those used in ecology studies regarding two-dimensional cyclic phenomena. This kind of two-dimensional dynamic can be illustrated using the prey–predator interaction described in the literature on dynamic systems (Lotka, 1925; Volterra, 1926). If the number of preys increases while the number of predators is low, the situation is favorable for predators and their population begins to increase. The number of preys will then rise more slowly and then begin to decrease as the number of predators reaches a given level. This decrease of the preys population will itself exert a negative influence on the number of predators. In the context of emotional regulation, one could imagine that an increase in NA, initially induced by a negative event, could produce a decrease in PA. If a low level of PA is reached regulation mechanism will then exert a force to restore it and will produce a rebound of PA. The main point is that this rebound of PA could occur before that NA has reached its maximum level as in the prey–predator example. This increase of PA will then exert a negative influence on the level of NA which will first increase slower and then begin to decrease. The combined forces of attraction and coupling would then lead to curved trajectories in the affective space.

To illustrate this phenomenon, the Fig. 3 shows the field lines for different levels of anxiety and daily life events. The graph was generated using an iterative procedure that involved taking the values predicted by the model during the first iteration as the start values for the following iteration, setting off from points located on the circumference of the shaded zone. The lines represent the trajectories expected, for these different starting points, if a non-anxious individual (at the top), moderately anxious (middle) or very anxious (at the bottom) were immersed in adverse environment (left), neutral (middle) or positive (right). This chart type is an alternative representation to vector fields that allows a better identification of the curvature of the trajectories.

Home bases were lying at the convergence of this field lines. Thus, whatever the starting point, the field lines end up to an equilibrium point, which reflects the attraction strength. We noted here that, in most cases, the field lines followed the direction of the downward diagonal in accordance with the idea of an inhibitor coupling effect between NA and PA. An increased in NA was associated with a decreased in PA and reciprocally most of the time. In some cases, the field lines do not point directly to the home bases and curved trajectories thus appeared. We can illustrate this phenomenon by following the field line that represents changes in the system in the wake of several positive events (e.g., a week's vacation; right-hand panels), starting in the neutral area (PA = 17, NA = 10). PA initially increases and NA decreases, but then, providing the environment remains favorable, as the system approaches the home base, the PA level starts to increase more slowly, while the NA level begins to rise (e.g., a few days into the vacation, negative thoughts resurface). A symmetrical phenomenon can be observed in the wake of negative events (e.g., stressful week at work, left-hand panels) especially for the less anxious subjects. Once again, on leaving the neutral area, the NA level initially increases (stress), while the PA level decreases (less sensitivity to positive events), but when the home base draws near, NA contin-

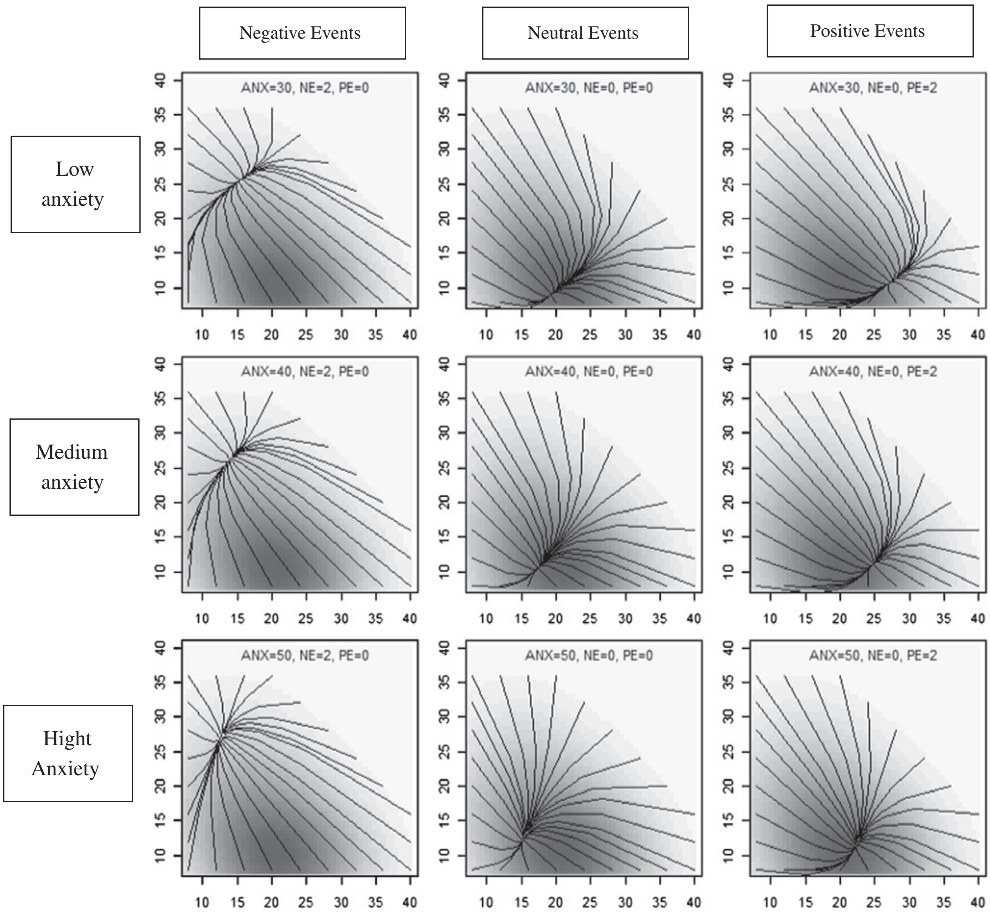

Fig. 3. Field lines for different levels of anxiety and life events. *Note*. The *x*-axis represents PA and the *y*-axis NA. Field lines for different levels of anxiety (Low anxiety = 30, Medium anxiety = 40, Hight Anxiety = 50) and different levels of daily life events (Negative Events = 2, Neutral Events = 0, Positive Events = 2). The graph (setting off from points located on the circumference of the shaded zone) was generated using an iterative procedure that simulates emotional reaction of persons immersed in adverse environment (left), neutral (middle) or positive (right).

ues to increase, but more slowly, while the PA level also starts to rise. It seems that a phenomenon of mobilization of PA to regulate NA occurred as if, when faced to an adverse environment, the level of anxiety and tension increased and the feeling of pleasure and joy decreased at first, but then those positive feelings reappeared to curb the increase in NA.

It is this curved movement that is sensitive to the effect of the interaction with anxiety levels, the curvature being particularly pronounced for the less anxious individuals. Fig. 4 is intended to make it easier to compare different field lines according to the level of anxiety. It shows how the field lines corresponding to different levels of trait anxiety link the home bases for neutral events to those associated with NEs. What we are effectively doing here is simulating the impact of NEs following a neutral period (top) and recovery after a series of NEs (bottom). On all four panels, the trajectories for the least anxious individuals display the steepest curves, graphically illustrating the effect of the NAt–1ANX interaction on PA (γ_{P21} std. = −.06, $p < .05$). The system's trajectory from the neutral home base in the direction of the home bases characterizing NEs (top) is initially characterized by an increase in NA, associated with a decline in PA. For very negative events (NE = 2), this decline in PA is more marked for less anxious individuals, whose affective state starts to resemble that of the anxious participants. The increase in NA then slows down and, for the least anxious participants, the PA level starts to rise again. The trajectory is straighter for the most anxious participants. It is as though, after a highly negative initial reaction to a series of NEs, relatively unanxious people managed to mobilize PA again and thus avoid the zone of high negative affectivity associated with very low positive affectivity, where the home base of the most anxious individuals is located (PA = 12.6; NA = 26.9 for ANX = 50 and NE = 2).

The field lines running in the opposite direction, from the home bases corresponding to NEs towards the neutral area (bottom), also display steeper curves for the least anxious individuals. The reduction in NA is accompanied first by an increase in PA, then by a reduction in the latter in the vicinity of the home bases. This back-and-forth motion is reminiscent of the damped oscillator model (Chow, Ram, Boker, Fujita, & Clore, 2005), except that the oscillations here primarily take place along an axis that is perpendicular to the main movement and would appear to stem from successive couplings and uncouplings between PA and NA. This phenomenon could correspond to a sensation of oscillation of positive and negative affects, but these two oscillations are not always synchronized. Sometimes we may feel an increased feeling of joy and pleasure associated with increased anxiety and stress.

4. Discussion

The present study tested the roles of anxiety and PA in emotion regulation by exploring the dynamic interaction between personality, events and emotions. We developed a dynamical system model of affective change based on the DynAffect model (Kuppens et al., 2010). In technical terms, we fitted a bivariate difference score model – treated as coupled linear models – to the data using GEE parameter estimation, and generated extensive graphical represen-

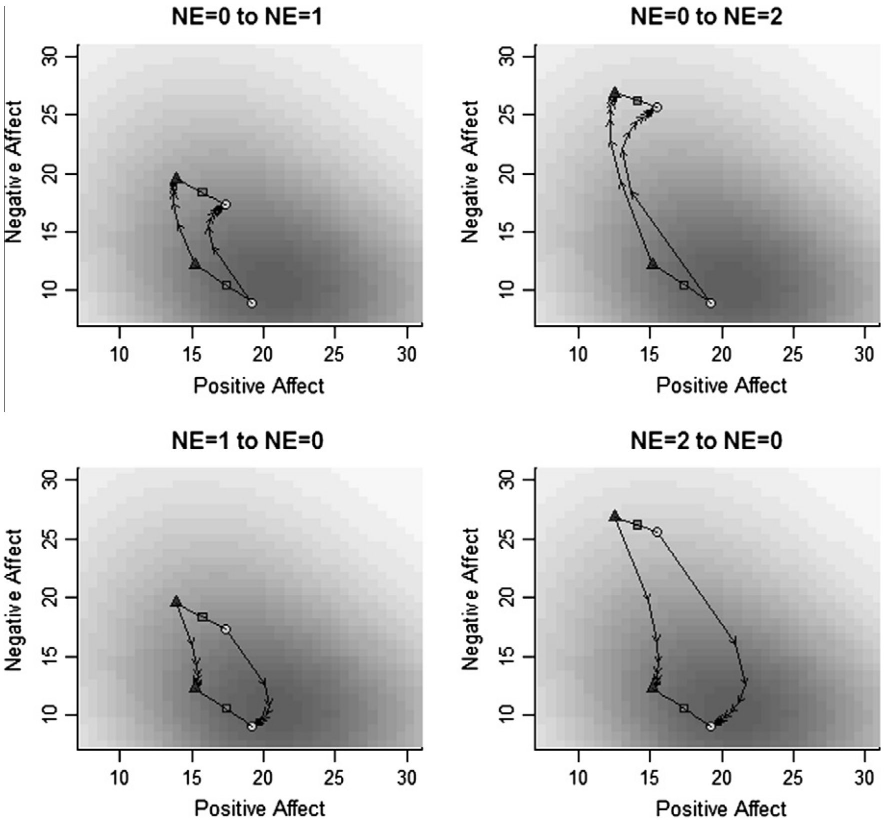

Fig. 4. Affective trajectories between the home bases corresponding to neutral and negative events as a function of anxiety level. *Note*. The top two panels represent the expected trajectories, from the neutral home bases to two negative home bases (NE = 1 in the left-hand panel and NE = 2 in the right-hand panel), for a low anxiety participant (ANX = 30; home bases represented by circles) and an anxious participant (ANX = 50, home bases represented by triangles). These trajectories would occur if a person was exposed to repeated negative events for 2 days following a neutral period. Conversely, the bottom two panels represent recovery from the negative (NE = 1) or very negative (NE = 2) home bases to the neutral home bases.

tations. We focused on three main processes that reflect individual differences: affective home bases, their attraction force and coupling effect between PA and NA. We adopted a longitudinal protocol in order to meet our two main objectives, namely describing the influence of anxiety on the position of affective home bases as a function of daily life events and highlighting the impact of anxiety on attractor strength and the coupling between PA and NA. More precisely, we posited four specific hypotheses: (1) the inclusion of life events in the model would lead to the identification of distinct home bases as a function of event valence, (2) trait anxiety would influence home base position, with more anxious individuals having more negative and less positive home bases and displaying greater reactivity to NEs, (3) anxiety would reduce attractor strength, which would be greater for less anxious individuals, reflecting more adaptive regulation processes, and (4) the evolution of NA could be under the influence of PA and reciprocally an this relation could be subject to individual differences related to trait anxiety.

Regarding the first hypothesis, results clearly showed an influence of PEs and NEs on the position of affective home bases, but this influence was not symmetrical. In line with Suls and Martin (2005)'s findings, NEs slightly reduced PA, compared with neutral events, and strongly increased NA. PEs had a clear effect on PA, causing it to rise, but there was no corresponding fall in NA. These results are congruent with models that postulate a relative independence of PA and NA for PEs, and a stronger negative correlation between the two for NEs (Reich et al., 2003).

The main effect of trait anxiety on home base position was as expected (Hypothesis 2), in that more anxious participants had less positive and more negative home base coordinates on the whole, possibly reflecting less efficient emotion regulation processes (Gomez & Francis, 2003; Zelenski & Larsen, 2002). Two significant interactions between daily life events and anxiety also emerged. The effect of anxiety on NA tended to disappear in reaction to very positive events, just as its effect on PA significantly decreased as the valence of NEs increased. We therefore observed the greatest anxiety-related differences between home bases for neutral situations. We failed to find any clear difference in reactions to NEs favoring low-anxiety participants, the pressure of the situation apparently tending to narrow individual differences, at least regarding home base position. One possible explanation for the lack of difference in affective responsiveness to NEs is that assessments of the valence of events varied across individuals, according to trait anxiety. This phenomenon was not taken into account in our model and an exploratory examination of the data showed that the correlation between affective state at time t and perceived valence of events encountered at time $t + 1$ was not null. The implementation of this type of retroactive procedure in the model went beyond the scope of this paper but could be an objective for future research.

Our third hypothesis was that attractor strength would be linked to trait anxiety. Attractor strength can be interpreted as reflecting individual regulatory processes that ensure the system's homeostasis and could thus be a source of individual differences. Attractor strength was technically implemented by the autoregressive coefficients linking PA and NA to the previous values along the same dimensions. The mean values of these coefficients were significantly higher than zero and descriptively far smaller than 1 (.54 for PA and .35 for NA), falling within the range of values that corresponded to a smooth gravitational pull exerted on the system by the attractor. The coefficient estimates were therefore compatible with the general representation of the dynamic processes. Regarding individual differences, no evidence was found of a relationship between trait anxiety and attractor strength. This result, albeit unexpected, was in line with Kuppens et al. (2010), who observed a relationship between attractor strength and personality on the arousal dimension but not on the valence dimension. In all likelihood, the effect of anxiety on attractor strength was masked in our model by an interaction between attractor strength and the home base coordinates, which varied as a function of anxiety. As we have already seen, home bases were farther apart for low-anxiety participants than for high anxiety ones. Accordingly, when moving from one home base to another, low-anxiety participants covered a greater distance. As attractor strength depends on the distance from the home base, low-anxiety individuals were subjected to a greater force. A careful inspection of Fig. 4 descriptively confirmed this hypothesis, as it seemed that the first moves in the recuperation phase were always faster for low-anxiety participants than for high anxiety ones, who may have had ineffectual emotion regulation skills (Zelenski & Larsen, 2002). It should be noted that the hypothesis of faster recovery after NEs by low-anxiety participants (Fredrickson et al., 2003; Zautra et al., 2005) corresponds to an asymmetrical interaction between anxiety and attractor strength, as it only applies to a downward move (decreasing NA). The asymmetrical implementation of attractor strength is one of the possible future directions of research.

Turning now to our fourth and final hypothesis, previous research on the effect of PA on NA regulation (Lyubomirsky et al., 2005; Ong et al., 2006) had shown that PA can enhance the efficiency of regulatory processes involved in coping with NEs. These results led us to hypothesize that PA levels would have to be taken into account in order to compute attractor strength on the NA axis. In graphical terms, introducing these cross-regression parameters into the model amounted to allowing for field line curvature reflecting coupling between AP and AN. Results clearly revealed nonlinear relationships between changes in PA and NA, and curved trajectories in affective space. These results showed that there was an interaction between the attraction strength and the inhibitory coupling which adds an element of understanding the emotional dynamics in DynAffect model (Kuppens et al., 2010). One can interpret this type of effect as follows. A negative event gives some reason to feel negative emotion. In itself this kind of event does not necessarily suppress the sources of positive affect in the environment of a person. A stressful deadline at work does not eliminate the sources of pleasure from friends or family. The main influence of a negative event is then supposed to be about the position of the home base on the NA-axis essentially. An increase in NA is then expected. Due to the inhibitory coupling effect, this increase in NA is associated with a decrease in PA. The stress induced by a deadline at work can prevent someone from feeling the joy of being with his family. The coupling effect has then pushed aside the affective state from its home base position on the PA axis. According to the model the attraction force exerted by the home base on the PA axis should induce a rebound in the PA level. If there are still some reasons to feel positive emotions in the environment, these positive emotions will reappear. The inhibitory coupling effect can then occur in the other direction. The increase in PA induced by the attraction force will curb the increase in NA originally produced by the negative event and help to recover.

We believe that coupling/uncoupling and the field line curvature reflected some kind of internal regulatory process. As a result, the effect of high or low trait anxiety on curvature for moves following NEs is of special interest. After an NE or during a difficult period, the trajectory of anxious participants was nearly straight: NA increased and PA decreased after the NE and they nearly followed the same path back during recovery. Low-anxiety individuals, however, had significantly more ellipsoidal trajectories. They avoided the zone of very high NA and very low PA, where the anxious participants' home base was located for very NEs, veering toward the right at high NA levels. This trajectory is not surprising, given the hypothesis that less anxious people can mobilize PA to cope with NEs and a high NA level (Tugade et al., 2004) or implement a positive reappraisal coping strategy. These results may also reflect the fact that low-anxiety persons may be more sensitive to positive aspects of the life that would enable them to mobilize AP.

Linking field line curvature with more accurately defined dispositional characteristics (coping style, optimism, etc.) or emotion regulation strategies (coping strategies, positive reappraisal, emotional suppression, etc.) could enhance our understanding of this phenomenon. These results raise questions about the mediating processes by which individuals cope with emotions and regulate them (Augustine & Hemenover, 2009).

5. Conclusion

Using a model of two-dimensional change encouraged us to stop seeing emotional reaction simply in terms of a causal relationship and instead to view it as a dynamic process of transaction between an individual and a situation. The bivariate difference score model allowed us to fit a dynamical system model using a standard statistical package and provided us with a means of integrating explanatory variables, such as trait anxiety and the perception of events, and the dynamics between positive and negative affectivity. As such, it enabled us to take our interpretation one step further. Adding arousal to PA and NA to create a three dimensional affective space (Stanley & Meyer, 2009) is one of the prospects for future research. Another original feature of the present study relates to the use of graphical representations, which we borrowed from the field of dynamical systems with a view to gaining a more accurate picture of the dynamic nature of these interactions and understand what happens over time. We were able to identify predictable, characteristic patterns of variations in individual behaviors across different situations as a function of trait anxiety, whilst integrating the dynamic relationship between positive and negative affectivity, which was presented in a two-dimensional affective space. The present study opens up several directions for future research, notably the asymmetrical nature of attractor strength and the impact of the individual's affective state on the perception of ongoing or future life events. Regarding the protocol, it would be worthwhile building in the individuals' subjective appraisals of the situation (other-blame, self-blame, danger/threat, loss/helplessness, achievement, positive encounters) to gain a more fine-grained understanding of the individual $*$ situation transaction (Nezlek, Vansteelandt, Van Mechelen, & Kuppens, 2008) and the stabilization of personality traits. From a more theoretical point of view, this would provide a means of elucidating the relationship between trait emotions and functional characteristics linked to the dynamic aspects of affective dysfunction. This type of model could provide a useful heuristic for characterizing the emotional phenomenology of psychopathological disorders which, at their core, are characterized by dysfonction. The different forms in which this affective dysfonction expresses itself may be associated with distinct combinations of the dynamic properties of affective home bases and attractor strength.

Appendix A

The home base coordinates can be determined analytically, using the coefficients that define the model, which can be regarded as a mathematical sequence.

$$PA_{it} = \beta_{P0} + \beta_{P1} PA_{it-1} + \beta_{P2} NA_{it-1} \tag{A.1}$$

$$NA_{it} = \beta_{N0} + \beta_{N1} NA_{it-1} + \beta_{N2} PA_{it-1} \tag{A.2}$$

This sequence converges when

$$PA_{it} = PA_{it-1} = \mu_P \tag{A.3}$$

and

$$NA_{it} = NA_{it-1} = \mu_N \tag{A.4}$$

By replacing PA_{it} and PA_{it-1} by μ_P and NA_{it} and NA_{it-1} by μ_N in (A.1) and (A.2), and after reorganization, we arrive at

$$\mu_P = \frac{\beta_{P0} + \beta_{P2}\mu_N}{(1 - \beta_{P1})} \tag{A.5}$$

$$\mu_N = \frac{\beta_{N0} + \beta_{N2}\mu_P}{(1 - \beta_{N1})} \tag{A.6}$$

By replacing μ_P in (A.6) by its expression in (A.5) and μ_N in (A.5) by its expression in (A.6), we arrive at

$$\mu_P = \frac{(1 - \beta_{N1})\beta_{P0} + \beta_{P2}\beta_{N0}}{(1 - \beta_{P1})(1 - \beta_{N1}) - \beta_{P2}\beta_{N2}} \tag{A.7}$$

$$\mu_N = \frac{(1 - \beta_{P1})\beta_{N0} + \beta_{N2}\beta_{P0}}{(1 - \beta_{P1})(1 - \beta_{N1}) - \beta_{P2}\beta_{N2}} \tag{A.8}$$

The transition equations define the variations in the state of the system between $t-1$ and t according to the distance between the state of the system at $t-1$ and its attractor. (A.1) and (A.2) can be reorganized as follows

$$PA_{it} - \beta_{P1}PA_{it-1} = \beta_{P0} + \beta_{P2}NA_{it-1}$$

$$PA_{it} - PA_{it-1} + PA_{it-1} - \beta_{P1}PA_{it-1} = \beta_{P0} + \beta_{P2}NA_{it-1}$$

$$PA_{it} - PA_{it-1} + (1 - \beta_{P1})PA_{it-1} = \beta_{P0} + \beta_{P2}NA_{it-1}$$

$$PA_{it} - PA_{it-1} = \beta_{P0} + (\beta_{P1} - 1)PA_{it-1} + \beta_{P2}NA_{it-1}$$

$$PA_{it} - PA_{it-1} = \beta_{P0} + (\beta_{P1} - 1)(PA_{it-1} - \mu_P + \mu_P) + \beta_{P2}(NA_{it-1} - \mu_N + \mu_N)$$

By partially replacing μ_P and μ_N by their expressions (A.5) and (A.6) and after simplification, we arrive at

$$PA_{it} - PA_{it-1} = (\beta_{P1} - 1)(PA_{it-1} - \mu_p) + \beta_{P2}(NA_{it-1} - \mu_N) \tag{A.9}$$

and by following the same procedure

$$NA_{it} - NA_{it-1} = (\beta_{N1} - 1)(NA_{it-1} - \mu_N) + \beta_{N2}(PA_{it-1} - \mu_P) \tag{A.10}$$

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