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Individual differences in core affect reactivity

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ABSTRACT

At the basis of any emotional phenomenon lies core affect, defined as a simple, volatile feeling that is a blend of hedonic and arousal values. The present study was intended to increase our understanding of core affect reactivity by investigating within-person relationships between two daily event characteristics and core affect, and individual differences in such relationships. For 7 days, 73 participants described their core affect nine times each day. Simultaneously, they rated the impact and valence of the most significant event that had occurred since the previous measurement occasion. Multilevel analyses found that the perceived event characteristics under study were significantly related to both core affect dimensions. Furthermore, individual differences in extraversion and neuroticism played a significant role in core affect reactivity. The different patterns of results for these traits suggest that omnibus models explaining how traits per se interact with situational forces to influence behaviour may need to be revised.

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1. Introduction

At the basis of any emotional phenomenon lies core affect, defined by Russell as "a neurophysiologic state that is consciously accessible as a simple, non-reflective feeling that is an integral blend of hedonic (pleasure–displeasure) and arousal (sleepy–activated) values" (Russell, 2003, p. 147). As such, the term core affect refers to the most elementary consciously accessible affective feelings that need not be directed at anything. At each moment in time, an individual's core affect can be depicted as a single point in a two-dimensional grid. The hedonic dimension of this grid ranges from pleasure through a neutral point to displeasure, and represents how well one is doing; the arousal dimension ranges from sleep through a neutral point to extreme excitement, and represents how energized an individual feels.

Core affect is not assumed to be stable but volatile: It moves through its constituting two-dimensional space, reflecting how one feels throughout everyday life. Moreover, core affect is subject to various influences (Russell & Feldman-Barrett, 1999). A full understanding of core affect therefore requires understanding its dynamics, including the different sources of core affect variability and their respective influences.

An important focus of studies on within-person variability of emotions has been the within-person relationship between daily events and emotions, or emotional reactivity. The majority of these studies have concerned changes in daily affect as a function of positive and negative daily events (e.g., David, Green, Martin, & Suls, 1997; van Eck, Nicolson, & Berkhof, 1998). More importantly, several studies have found individual differences in the within-person relationships between daily events and daily affect in terms of neuroticism or extraversion (e.g., Lucas & Baird, 2004; Suls & Martin, 2005) and measures of well-being such as depression (e.g., Nezlek & Plesko, 2003). For example, Lucas and Baird (2004) found reliable evidence that extraverts were happier than introverts in both neutral and positive mood conditions, whereas Suls and Martin (2005) showed that persons who scored high (versus low) in neuroticism tended to experience more severe emotions in response to daily stressors.

These results suggested that it would be useful to examine individual differences in the relationships between core affect and characteristics of the events people experience in their everyday lives. Such within-person relationships might vary straightforwardly as a function of dispositional measures, but individual differences might also show up in more complex ways. For example, as suggested by Marshall and Brown (2006), individual differences in emotional reactivity might vary as a joint function of dispositional factors and the strength of situational characteristics. In their presentation of the TASS model (traits as situational sensitivities), Marshall and Brown (2006) found support for the hypothesis that dispositional factors would be more influential when situational characteristics are moderate in strength compared to when situational characteristics are either strong or weak.

In this article we focus on two different types of event characteristics reflecting the hedonic and arousal dimensions of core affect, the perceived valence and impact of an event. Consider, for

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example, an individual meeting with a friend *Y* and this friend starts talking about his new job. If we ask individual *X* to rate this event, he would probably rate it as a positive event with a low impact. Now, consider the situation where an employer accuses *X* of having made a mistake. *X* would probably rate this as a negative event with more impact than the previous example because of its greater importance and relevance. It is important to note that the perceived valence and impact of an event are conceptualized as independent.

In general, we hypothesize that event valence is positively related to the hedonic dimension of core affect, in line with previous findings of Marco, Neale, Schwartz, Shiffman, and Stone (1999), and van Eck et al. (1998). We further hypothesize that more impactful events result in higher arousal levels of core affect, similar to the relationships between emotions and the primary appraisals of event importance and motivational relevance, as described by Smith and Lazarus (1990) and Sonnemans and Frijda (1995).

Moreover, we examined individual differences in the relationships between event characteristics and core affect. Our specific research questions concerned individual differences in extraversion and neuroticism.[1] With regard to *extraversion*, we based our expectations in part on research and theory concerning physiologically based personality theories (e.g., Beauducel, Brocke, & Leue, 2006; Eysenck, 1967; Eysenck & Eysenck, 1985). Broadly speaking, these theories suggest that introverts have higher levels of brain activity in the ascending reticular activating system (ARAS) than extraverts, and as a consequence, introverts display more reactivity on the arousal dimension of the affective circumplex. Based on these theories, different predictions could be made for the present study. Base-line arousal models suggest a main effect: introverts should be more aroused than extraverts, regardless of the impact of an event. Taking into account individual differences in reactivity suggests one of two interactions. (1) Introverts and extraverts should be similarly aroused when events have no impact, but introverts should be more aroused when there is some impact. (2) Introverts should be more aroused than extraverts, and this difference should increase as event impact increases.

With regard to *neuroticism*, our research questions concerned relationships between the hedonic dimension and neuroticism. Based on previous research different predictions could be made for the present study. Consistent with research that has found relationships between neuroticism and experienced negative emotions such as anxiety (e.g., Gomez & Francis, 2003) and negative emotionality (Larsen & Ketelaar, 1991), we had reason to expect a main effect of neuroticism. Overall, we expected that more (as compared to fewer) neurotic individuals would be more likely to report feelings in the negative half of core affective space. Moreover, we expected this negative relationship between neuroticism and the hedonic dimension across all levels of event impact. In addition, as suggested by Marshall and Brown (2006), we examined the possibility of an interaction effect to occur between neuroticism and impact. Neuroticism might be negatively related to pleasure in the case of low or moderate impact events, whereas they might not be related for high impact events because the strength of the situation would override such individual differences. Individual differences might also be weak in situations without any impact. Such expectations are also suggested by Snyder and Ickes (1985) and Mischel (1977) who stated that traits have their greatest predictive ability when situations provide just enough provocation to evoke trait-relevant reactions in those who score high on a trait but not in those who score low. Taking all this together, we had reason to expect that relationships between neuroticism and pleasure would be strongest in situations of moderate impact.

We examined these questions by conducting an experience sampling study in which participants described their experienced core affect and the valence and impact of events at random moments during their daily activities. They also completed various dispositional measures. There are numerous advantages of using experience sampling to examine the types of relationships in which we were interested. These include diminished reliance on memory and a consequent reduction of distortion (e.g., Stone et al., 1998) and the ability to sample variables in a broad range of every day circumstances, increasing ecological validity (Feldman-Barrett & Barrett, 2001).

2. Method

2.1. Participants

Participants were 73 students from the University of Leuven. The sample consisted of 26 men and 47 women. On average, participants were 21.22 years old (SD = 2.10).

2.2. Measures of core affect and event characteristics

Core affect was measured with the Affect Grid (Russell, Weiss, & Mendelsohn, 1989), a visual 9×9 two-dimensional grid, with a neutral (fifth) row and a neutral (fifth) column. Unpleasant/pleasant constitutes the horizontal and arousal/sleepiness the vertical dimension of this grid. Fig. 1 provides an example of the Affect Grid. Event impact was measured with a 7-point scale with 0 = nothing impactful happened, and 6 = extremely impactful, and event valence with a 7-point scale with −3 = negative, 0 = neutral, and 3 = positive.

2.3. Personality measures

The Dutch version of the NEO-FFI (Hoekstra, Ormel, & De Fruyt, 1996) was used to measure neuroticism and extraversion. All items

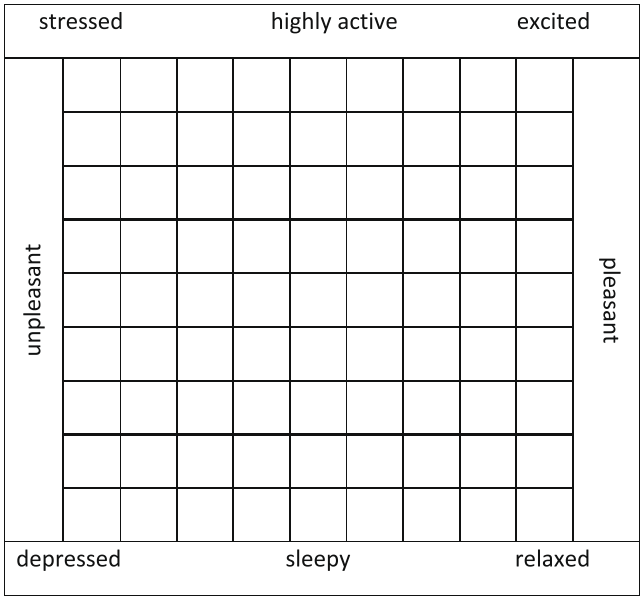


Fig. 1. The Affect Grid used to assess momentary core affect (adapted from Russell et al. (1989)).

[1] To simplify the presentation of the research questions, we use the terms "introverts" and "extraverts" to refer to those low and high (respectively) on the personality dimension of extraversion. We use a similar convention when discussing neuroticism. In neither case are we assuming a categorical or discontinuous distribution of the trait.

were rated on a 5-point scale ranging from 1 = strongly disagree to 5 = strongly agree. Cronbach's alpha was .85 for neuroticism and .80 for extraversion. Research has indicated that the NEO-FFI has convergent and discriminant validity (for example, see McCrae & Costa, 2004). To ease interpretation, these scores were standardized for the multilevel analyses (Nezlek, 2001).

2.4. Procedure

During an individual introductory session, participants received instructions, a digital wristwatch, and seven booklets (one booklet a day) each containing nine copies of the Affect Grid, and a brief event questionnaire. Starting the next day, they received nine beeps a day for seven consecutive days (9 beeps × 7 days = 63 beeps). The beeps were programmed according to a stratified random interval scheme: The total amount of available daytime was divided into equal intervals, and a random beep was scheduled in each interval. The time of the first and last beep was prespecified on an individual basis. After each beep, participants indicated their momentary core affect using the Core Affect Grid, and they rated the most significant event that had occurred between the previous beep and the current beep in terms of the event's impact and valence, without giving specific details about the event. At the end of each questionnaire, participants described the time at which they had completed it. At the end of the experience sampling procedure, participants attended a second meeting during which they completed the NEO-FFI personality questionnaire, they returned their watches, and they were paid.

Compliance with the experience sampling procedure was generally very good. In total 94% of reports were provided within a specified timeframe of a [5, 10] min' interval around the programmed time. This indicates excellent compliance given that response rates usually fall between .70 and .80 or lower in experience sampling studies (e.g., Hektner & Csikszentmihalyi, 2002).

2.5. Analysis

The data we collected had a multilevel structure in that observations at one level of analysis (Level 1 or occasion level) were nested within another level (Level 2 or day level), which in turn was nested within a third level (Level 3 or person level). Accordingly, the data were analyzed with three-level random coefficient models with the arousal or hedonic dimension of core affect as a criterion and event characteristics (impact and valence) as predictors. The data were analyzed using HLM 6.0 (Raudenbush, Bryk, Cheong, & Congdon, 2004).

Before the multilevel analyses, we examined the distributions of event impact and valence. To take into account the skewness of the event's impact (with only 6% having been rated 4 or more), we recoded this characteristic into a categorical variable with four dummy variables, denoting an impact of 0 (nothing impactful happened), 1 (low impact), 2 (moderate impact), and 3 or more (high impact). Valence ratings were included as a continuous variable.

The basic level 1 equation for the arousal dimension of core affect was a no-intercept model that included four dummy variables representing the different levels of impact, and one continuous variable, i.e., valence (VAL), as predictors, all entered uncentered. A model with 4 dummy codes estimates a mean response for each of the different levels of impact. In terms of our hypotheses, these estimates allowed us to examine relationships between trait measures and outcomes at different levels of impact.

$$A_{ijk} = \beta_{1jk}\,(\mathrm{No})_{ijk} + \beta_{2jk}\,(\mathrm{Low})_{ijk} + \beta_{3jk}\,(\mathrm{Mod})_{ijk} + \beta_{4jk}\,(\mathrm{High})_{ijk} + \beta_{5jk}\,(\mathrm{VAL})_{ijk} + e_{ijk}$$

In these models, A_{ijk} is the score on the arousal dimension for occasion i ($i = 1, \ldots, 9$), on day j ($j = 1, \ldots, 7$), for person k ($k = 1, \ldots, 73$). The coefficients β_{1jk} to β_{4jk} represent the estimated occasion-level means on experienced arousal for no, low, moderate, and high impact events respectively, and β_{5jk} is a person specific regression weight denoting the effect of event valence on the experienced arousal level. The error associated with each measure is represented by e_{ijk}.

These occasion-level means were then analyzed at the day-level using the following model. This model did not include any predictors, only a day-specific intercept and a random error term.

$$\beta_{ljk} = \alpha_{10k} + r_{ljk} \quad (l = 1, \ldots, 5)$$

Finally, these day-level means were then analyzed at the person-level (Level 3).

$$\alpha_{10k} = \gamma_{100} + u_{lk} \quad (l = 1, \ldots, 5)$$

These models allowed us to examine relationships between dispositional measures and the arousal dimension of core affect for events of differing impacts and valence by including predictors in the person level models.

With regard to the hedonic dimension of core affect, we performed similar analyses as we did for arousal.

3. Results

3.1. Descriptive statistics

As a preliminary step, we performed a totally unconditional analysis of the arousal, pleasantness, and valence ratings to decompose the overall variance into the variances associated with the different levels. The results, including estimated means are presented in Table 1. The mean event is mildly positive ($M = 0.31$) (and greater than the scale midpoint of 0, $t = 16.70$, $p < .001$) but not very impactful ($M = 0.99$) (i.e., smaller than the scale midpoint of 3, $t = 100.97$, $p < .001$). Looking individually at events, the majority of the events was rated as positive for 60 out of the 73 participants, and had an impact rating of one or less for 38 participants.

3.2. The relationship between the arousal dimension of core affect and event characteristics

To examine the relationship between arousal and event impact and valence, a three level multilevel model was estimated as described above. The results of these analyses are presented in Table 2. Event impact as well as the valence of an event clearly had an effect on experienced arousal. Differences in arousal as a function of event impact were tested via a series of constraints on the model (e.g., Nezlek, 2001) that constrained pairs of coefficients to be equal. These analyses indicated that experienced arousal increased as a function of event impact. Arousal was greater in high impact events than in all other types of events (all $ps < .01$), moderate impact events were significantly more arousing than low or no impact events (all $ps < .001$), and low impact events were significantly more arousing than no impact events ($p < .001$).

Table 1
Descriptive statistics for core affect and situational ratings.

	Mean	Variance		
		Occasion	Day	Person
Arousal	5.28	3.20	0.38	0.28
Pleasure	5.90	2.49	0.52	0.36
Event valence	0.31	1.25	0.08	0.05

Table 2
Means and variance of core affect as a function of event.

Event impact and valence	Arousal		Pleasantness	
	Mean	Random error	Mean	Random error
No	4.81	.34***	5.87	.52***
Low	5.34	41***	5.41	.19***
Moderate	5.78	.36***	5.34	.18***
High	6.14	.70***	5.21	.12***
Valence	0.14	.04**	1.02	.03***

** $p < .01$.
*** $p < .001$

An important focus of our study was individual differences in reactions to events. Examination of the random error terms for the person levels indicated that there were statistically significant individual differences in how participants reacted to events differing in impact and valence, and these error terms are presented in Table 2. One of our primary research questions concerned relationships between extraversion and experienced arousal, and to test these hypotheses, we modeled individual differences in arousal as a function of extraversion. These analyses revealed that extraversion was positively related to experienced arousal for no and low impact events, and was negatively related for high impact events. These results are presented in Table 3.

Analyses comparing the strength of the relationships between extraversion and arousal across the four levels of arousal (using the types of constraints discussed above) found that the relationship between extraversion and arousal for high impact events was significantly different from the relationship for all other types of event (all *ps* < .001). No other comparison produced a significant difference (all *ps* > .2). Extraversion did not moderate relationships between arousal and valence ($t = 1.55$, *ns*). Differences in the relationship between extraversion and experienced arousal as a function of event impact are depicted in Fig. 2.

3.3. The relationship between the hedonic dimension of core affect and event characteristics

To examine the relationship between the hedonic dimension of core affect and event impact and valence, a multilevel model with three equations that was structurally identical to that used to analyze arousal was estimated. The results of this analysis are presented in Table 2. Differences in pleasure as a function of event impact were tested via a series of constraints similar to those used to examine differences in arousal as a function of event impact. These analyses indicated that pleasantness was negatively related to impact. No impact events were significantly more pleasant than all other types of events (all *ps* < .001), low impact events were significantly more pleasant than high impact events ($p < .01$), and moderate impact events were more pleasant than high impact events ($p = .05$).

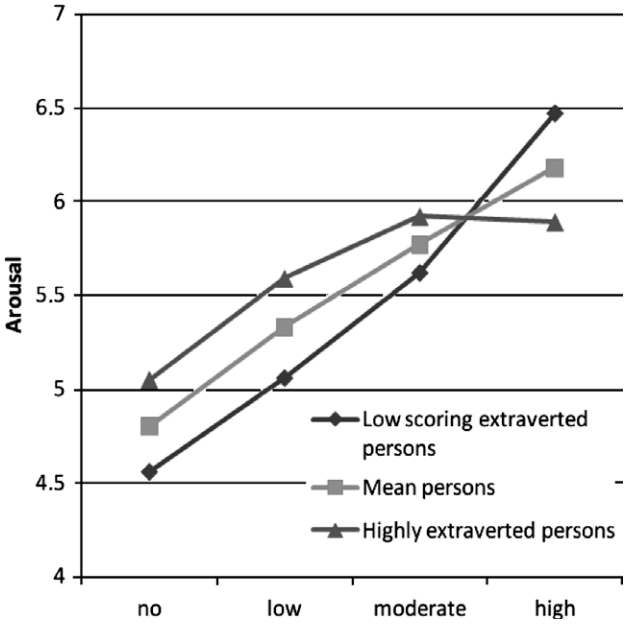


Fig. 2. Graphical depiction of individual differences in the relationship between arousal and event impact indicating the arousal level of (a) mean person, (b) a highly extraverted person (a score of one standard deviation above the mean) and (c) a low scoring extraverted person (a score of one standard deviation below the mean). Event valence is kept constant at the mean.

We were also interested in how relationships between pleasantness and neuroticism might vary as a function of event impact. Examination of the random error terms for the models that included event impact at level 1 indicated that there were significant individual differences in experienced pleasantness in events of all level of impact. The corresponding person level variance estimates were all significant and are presented in Table 2. To examine relationships between neuroticism and experienced pleasantness, we modeled individual differences in pleasantness as a function of neuroticism (at the person level). The results are presented in Table 3.

These analyses revealed that neuroticism was significantly and negatively related to experienced pleasantness for events at all levels of impact. Analyses comparing the strength of the relationships between neuroticism and pleasantness across the four levels of impact found that the relationship between neuroticism and pleasantness was stronger for no impact events than it was for all other types of events (versus low, $p < .001$; moderate, $p < .05$; and high, $p = .11$). No other comparison produced a significant difference (*all ps* > .5). Neuroticism did not moderate relationships between pleasantness and valence ($t = 1.47$, *ns*). Differences in the relationship between neuroticism and pleasantness as a function of event impact are depicted in Fig. 3.

Table 3
Relationships between dispositional measures and core affect as a function of event impact.

Event impact and valence	Extraversion-arousal	*t*-Ratio	Neuroticism-pleasantness	*t*-Ratio
No	0.25	3.08**	−0.35	3.73**
Low	0.27	2.82**	−0.16	2.03*
Moderate	0.15		−0.20	2.51*
High	−0.29	2.32*	−0.20	2.95**
Valence	.05		.04	

* $p < .05$.
** $p < .01$.

4. Discussion

The results of our analyses demonstrate that both event impact and event valence influence core affect. We found that event valence was positively related to both experienced arousal and pleasantness (see also Marco et al., 1999). We also found that impact influenced both the hedonic and arousal dimensions: higher impact resulted in more arousal and less pleasantness. The positive relationship between impact and arousal replicates previous research (e.g., Schimmack & Diener, 1997).

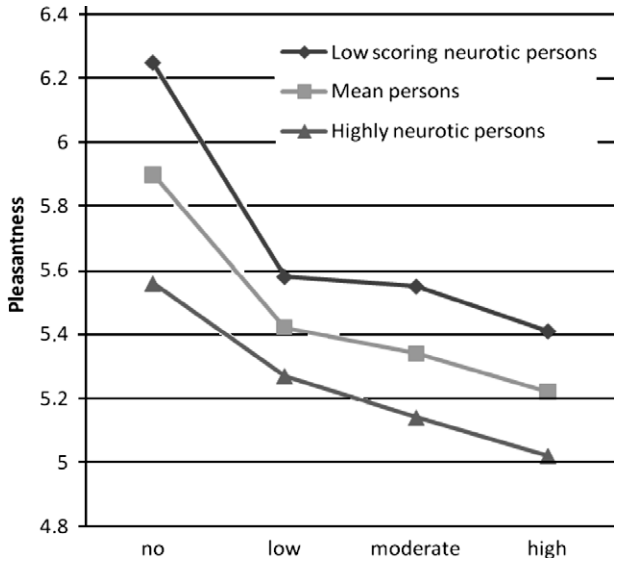


Fig. 3. Graphical depiction of individual differences in the relationship between the hedonic dimension of core affect and event impact indicating the pleasantness level of (a) mean person, (b) a highly neurotic person (a score of one standard deviation above the mean), and (c) a low scoring neurotic person (a score of one standard deviation below the mean). Event valence is kept constant at the mean.

In contrast, the relationship between event impact and pleasantness was less straightforward. Pleasantness was positively related to impact for positive events and was negatively related to impact for negative events. Although not part of our hypotheses, these results make sense. Impact was meant to represent personal meaningfulness or relevance. So, more meaningful positive events were more pleasant than less meaningful positive events, and more meaningful negative events were less pleasant than less meaningful negative events. Furthermore, we found individual differences in the relationships between event impact and valence and the two core affect dimensions. Below, we describe these results in terms of our earlier predictions.

In terms of extraversion and arousal, the base-line approach (e.g., Eysenck, 1967) suggested that introverts should be more aroused than extraverts across different levels of event impact. We found no support for this prediction, although we did find support for an interactionist position. At lower levels of impact (no, low, and moderate) extraversion was positively related to arousal, whereas at high levels of impact, extraversion was negatively related to arousal. The negative relationship between extraversion and arousal for high impact events is consistent with existing models: introverts have a higher level of brain activity in the ARAS than extraverts and therefore they feel more aroused when impact is high.

In contrast, the finding that at lower levels of impact extraverts were more aroused than introverts contradicts such models. A possible explanation for these results rests on the assumption that at low levels of impact, extraverts are more likely than introverts to seek stimulation to compensate for their lower levels of baseline activation (Matthews & Gilliland, 1999; Thayer, Newman, & McClain, 1994); as a result they will then feel more aroused than introverts. At higher levels of impact, differences in stimulation seeking may not be influential because, by definition, high impact events provide a lot of stimulation; hence, so experienced arousal will then reflect the physiologically based process as described by Eysenck. Clearly, such an explanation requires further validation; nevertheless, it represents a consistent way of understanding results in our study that are at odds with previous research.

In terms of neuroticism and pleasantness, base-line theories (e.g., Larsen & Ketelaar, 1991) suggested that neuroticism should be negatively related to experienced pleasure across different levels of event impact. We found strong support for this prediction. Neuroticism was negatively related to pleasantness at all four levels of event impact. We also found support for an interactionist approach in that neuroticism was related most strongly to pleasantness for no impact events than it was for other types of events. Such differences are somewhat consistent with Marshall and Brown's (2006) position. When situational forces were very weak, emotional pleasantness was determined more by neuroticism than when situational forces were stronger. Nevertheless, our results suggest that such "turning points" may be very low, at least in the case of neuroticism.

The different pattern of results for neuroticism and extraversion suggests that omnibus models that explain how traits (or dispositions) per se interact with situational forces to influence behaviour (or other states) may need to be revised. It may be that some trait–state relationships are governed by one set of rules (e.g., low situational forces allow traits to be manifested more readily), whereas others are governed by a different set (e.g., differences in the direction of trait–state relationships across levels of situational forces). At the least, the present results suggest that such possibilities need to be considered more closely.

Certainly, the present study has limitations. Our sample had more women than men, but separate analyses for men and women did not reveal any differences. We measured situational forces, reaction to these forces, and dispositions in certain ways. Other measures of such constructs may have produced different results. Furthermore, reports of events were self-reports, and more objective reports of events might lead to different conclusions. Also, although no data suggest such a possibility, it is possible that relationships between core affect and reports of events were influenced by the fact that event ratings were obtained after the core affect experiences were reported. Finally, we could not verify that participants provided data when they were supposed to, although we have no reason to believe that they systematically failed to comply with instructions.

Nonetheless, we believe that the present results demonstrate that studying the naturally occurring variability of core affect can provide important insights into the study of personality. More specifically, we think that understanding relationships between core affect and situational characteristics and the individual differences in such relationships can contribute to our understanding of the situational specificity of traits and dispositions and interactionist approaches to personality in general.

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