



The dynamic relationships of affective synchrony to perceptions of situations

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ABSTRACT

Most theories of affect predict that affects of opposite valence should be negatively correlated (de-synchronous) or independent (asynchronous) within individuals. Such theories were challenged by the finding that the association between energetic arousal and tense arousal ranged from de-synchrony to synchrony (Rafaeli, Rogers, & Revelle, 2007). In this paper, we report two experience-sampling studies employing cell-phone text-messaging aimed at further exploring individual differences in affective experience. Results showed that within-person relationships between energetic arousal and tense arousal ranged from de-synchrony to synchrony, but that within-person relationships between Pleasant and Unpleasant affect varied from strong de-synchrony to weak de-synchrony. Individual differences in within-person EA–TA associations were related to perceiving threatening situations as incentives and to interactions between affective traits.

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1. Introduction

In rare but especially meaningful situations, humans have the capability to experience mixed emotions. Graduations, moving out, emotionally complex movies (e.g., *Life is Beautiful*), and meaningful endings and beginnings (e.g., first day of school) can move people to feeling mixtures of happiness and sadness at the same time (Ersner-Hershfield, Mikels, Sullivan, & Carstensen, 2008; Larsen, McGraw, & Cacioppo, 2001; Wildschut, Sedikides, Arndt, & Routledge, 2006). Mixed emotions may also occur in more mundane situations, such as when listening to music with conflicting tempo and mode cues (Hunter, Schellenberg, & Schimmack, 2008), winning less money than expected – or losing less money than expected (Larsen, McGraw, Mellers, & Cacioppo, 2004), and watching a clip of disgusting humor (Hemenover & Schimmack, 2007). Not only do some *situations* and events provoke mixed emotions, but recent research shows that some *people* are also more likely than others to experience positivity and negativity at the same time (Rafaeli et al., 2007). That is, the typical emotional experience for some *individuals* is a blend of positive and negative affects whereas for others positivity and negativity are inversely related or unrelated to each other. With few exceptions (Hui, Fok, & Bond, 2009; Ong & Bergeman, 2004; Rafaeli et al., 2007), there has been little research exploring individual differences in the tendency to experience mixed emotions. The current paper investigates some of the pressing questions in this domain.

Several prominent theories of affect predict that momentary affects of opposite valence (e.g., positive and negative, happiness and sadness) should be either negatively correlated (de-synchrony) or independent (asynchrony) within individuals (Gray, van Goozen, Van de Poll, & Sergeant, 1994; Russell & Carroll, 1999; Solomon, 1980). In contrast, Thayer (1989) presented models of momentary arousal which predict that energetic and tense states may occur simultaneously (synchrony), in addition to de-synchrony and asynchrony (Thayer, 1989). Importantly, these theories were concerned with the *average or typical* affective experience, and therefore none of these theories addressed the possibility of individual differences in within-person affective experience (i.e., the possibility that the within-person relationship between positive and negative emotions may differ across individuals).

An early investigation into individual differences in within-person correlations between affects (Rafaeli et al., 2007) revealed that not only was affective experience typically de-synchronous for some individuals and asynchronous for others, but also that there are some people who experience a positive correlation, or synchrony, between affects of opposite valence. Thus, the continuum on which people differ in their momentary correlation between positive and negative affects ranges from de-synchrony to synchrony. In the current paper, we present two studies that further clarify (1) which positive and negative affects may typically occur synchronously for some individuals and (2) which individuals are more likely to experience affective synchrony.

2. Affective synchrony

The dimension reflecting individual differences in within-person correlations between positive and negative affects is termed

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affective synchrony (Rafaeli et al., 2007). Affective synchrony may be thought of like any other trait dimension in personality psychology. This trait is anchored at one pole by de-synchrony and at the other by synchrony. Individuals who typically experience positive and negative affects together are described as synchronous; individuals who experience positive and negative affect independently are described as asynchronous; and individuals with an inverse relationship between positive and negative affects are described as de-synchronous.

Rafaeli et al. (2007) observed affective synchrony by tracking individuals' emotional experience over time using paper-and-pencil dairies and personal digital assistants. Across five studies, participants rated how they felt along the affective dimensions of energetic arousal (EA; tiredness–wakefulness) and tense arousal (TA; relaxation–tension) every three waking hours for up to two weeks. Multilevel-modeling (MLM) analyses revealed that the relationship of EA to TA was close to zero (asynchronous) on average, but also that some individuals' relationships between EA and TA were reliably de-synchronous and that others were reliably synchronous. Three of the five studies assessed the temporal stability, and results indicated that affective synchrony showed similar temporal stability (test-retest $r_s = .39, .43, \text{ and } .65$ over two non-consecutive weeks) to that of mean levels of positive affect and negative affect (Watson, Clark, & Tellegen, 1988).

The current studies aim to build on Rafaeli et al. (2007) in two ways. Our first purpose is to determine which dimensions of positive and negative affectivity may occur together. Our second aim is to examine some of the factors that may account for individual differences in affective synchrony. We do this by introducing a new way of collecting experiential data.

3. Situating energetic arousal, tense arousal, Pleasant affect, and Unpleasant affect in two-dimensional and three-dimensional affective space

When averaged across individuals, affective space may be described by a circumplex, defined as a circular arrangement of affective adjectives around two orthogonal dimensions (Larsen & Diener, 1992; Russell, Lewicka, & Niit, 1989). However, it is unclear as to which dimensions of affect are fundamental or causal. As described in the previous section, Rafaeli et al. (2007) chose to use the putatively independent dimensions of EA and TA to represent affective dimensions based on numerous findings that support this conceptualization. For example, EA and TA are affected differently by exercise and relaxation (Saklofske, Blomme, & Kelly, 1992), and EA (but not TA) is related to a circadian rhythm (Watson, Wiese, Vaidya, & Tellegen, 1999) and cognitive performance (Matthews & Westerman, 1994). Nonetheless, various researchers have been critical of the conclusion that positive and negative emotions represent independent dimensions (Barrett & Russell, 1998; Yik, Russell, & Barrett, 1999), proposing instead that the fundamental dimensions of the affective circumplex should be represented by a bipolar valence dimension (Unpleasant–Pleasant) and a single dimension of activation (deactivated–activated). Schimmack and Reizenzein (2002) attempted to reconcile these differing perspectives, reasoning that, if activation could be reduced to a single dimension, then the correlation between EA and TA (after accounting for valence) should be positive. However, this prediction was disconfirmed by the finding that the correlation between EA and TA was not different from zero after residualizing for valence. This study also found that valence was positively correlated with EA and negatively correlated with TA, consistent with a *three-dimensional* structure of affect (EA, TA, and valence) reported previously (Schimmack and Grob (2000).

The findings of Schimmack and Reizenzein (2002) raise an important question for the study of synchrony: which positive

and negative affects may be experienced synchronously within individuals? To rephrase, the question of whether positive and negative affects occur together should be more accurately rephrased as two separate questions: (1) do EA and TA occur together?; and (2) do Pleasant and Unpleasant affects occur together? Because EA and TA are thought to represent independent dimensions of positivity and negativity (Schimmack & Reizenzein, 2002), it stands to reason that the positive emotions associated with EA and the negative emotions associated with TA may be experienced synchronously for some individuals. Indeed, this prediction was supported by Rafaeli et al. (2007). However, there has yet to be an investigation into the potential synchrony of positive and negative affects represented by Pleasant and Unpleasant affective dimensions.¹ Therefore, we aim to replicate Rafaeli et al. (2007) by examining the range of within-person correlations between EA and TA, and we also extend that study by examining the range of within-person correlations between Pleasant and Unpleasant affects.

4. Explaining individual differences in affective synchrony: the potential role of cognitive appraisals

What accounts for individual differences in affective synchrony? Across multiple studies, Rafaeli et al. (2007) found that synchrony was unrelated to various dispositional characteristics that have previously been associated with both positive emotional experience (extraversion, sociability, and impulsivity) and negative emotional experience (neuroticism); furthermore, mean levels and variability of EA and TA from the experience sampling data did not relate to synchrony. These characteristics were chosen by Rafaeli et al. as potential predictors of synchrony because of each construct is thought to tap into emotional reactivity. Therefore, null relationships between synchrony and those traits importantly showed that synchrony could be distinguished from well-validated emotional constructs.

In the current studies, we go beyond testing for relationships between traits and synchrony to examine the idea that synchrony relates to individual differences in dynamic cognitive appraisals. In doing so, we draw from Zautra and colleagues' *dynamic model* (Reich, Zautra, & Davis, 2003; Zautra, Berkhof, & Nicolson, 2002; Zautra, 2003) as well as two models described by Thayer (1989), the (1) *activating events model* and (2) *requirements vs. resources imbalance model*; each of these models predicts that one's affective space should vary as a function of dynamic cognitive resources and appraisals.

The *dynamic model* is particularly concerned with how complexity of information processing relates to one's experience of affect (Reich et al., 2003). The degree of complexity of information processing one engages in is thought to be determined by perceptions of threat in the environment. When perceptions of threat are low, attentional resources are not constrained and may be flexibly

¹ It is important to reiterate that, for this study, we conceptualize affective space in the three-dimensional model described above. Individual differences in representations of two-dimensional, circumplex affective space have been studied in the context of the competing tendencies of valence focus and arousal focus (Feldman, 1995). Individuals high in valence focus tend to describe their affective experiences by using adjectives on the Pleasantness–Unpleasantness dimension; for these individuals, the affective circumplex resembles a bipolar positive negative dimension. Therefore, individuals high in valence focus describe their experience as either positive or negative, resulting in a more de-synchronous experience of affect (Rafaeli et al., 2007). Individuals high in arousal focus describe their affective experiences using adjectives reflecting a bipolar dimension high or low arousal, not differentiating between the dimensions of EA and TA. As such, arousal focus is related to synchronous experience of EA and TA. Other studies might find it more fruitful to conceive of individual differences in affective space using the circumplex model and employing the constructs of valence focus and arousal focus; however, we chose against doing so in this study because it collapses across the separable dimensions of EA and TA.

deployed across a broad array of stimuli. Individuals are thus able to engage in complex information processing and become aware of both positive and negative affects independently (asynchrony). In contrast, when perceptions of threat are high, attentional resources become constrained and a reduction in complexity of information processing takes place. Affects of opposite valence should thus tend to collapse into a simple bipolar dimension (de-synchrony) under conditions of high threat. Various studies have supported the dynamic model in finding that increased situational stress is associated with a more bipolar experience of positivity and negativity (e.g., Coifman, Bonanno, & Rafaeli, 2007).

The models presented by Thayer (1989) are also concerned with how perceptions of threat influence affect, but they go further in that they also take into account the individual's perceptions of resources available to deal with potential threats. Thayer first states that the perception of threat increases negative affect states (TA). When threats are perceived as severe enough to exceed one's actual resources (*activating events model*), or perceived resources (*requirements vs. resources model*), then individuals should experience an increase in TA and a reduction in EA. The rationale for this prediction is that when stressors are perceived as unmanageably threatening, TA will increase to foster avoidance, and EA will decrease so as to inhibit approach. Thus, the dynamic model and Thayer's models together predict that affect should become more de-synchronous in situations in which threat is the prominent appraisal. Thayer's models specify further the relationship between perceptions of threat and covariation of positive and negative affects. Specifically, they state that when threats are perceived as manageable and that a reward may be obtained by confronting and overcoming the threat, then individuals will experience an increase in both avoidance processes (TA) as well as approach processes (EA). Therefore, synchrony (positive association between positive and negative affects) should occur when perceived threats are also perceived as potential opportunities for reward.

Importantly, neither Zautra's model nor Thayer's models touch on the possibility of *individual differences* in the experience in the relationship between positive and negative affects. We attempt to extend the assumptions of each model to predicting individual differences in synchrony. Specifically, we reason that (i) if viewing stressful *situations* as predominantly threatening produces de-synchrony, then *individuals* who view stressors predominantly as threats (rather than incentives) may experience affect in a more de-synchronous fashion; we also reason that (ii) if viewing stressful *situations* as challenges that present an opportunity for reward, then *individuals* who typically perceive stressors as possible incentives may experience affect more synchronously. We test these predictions in the current studies.

5. Cell-phone text-messaging as a new method for studying affective experience over time

The aims of this paper require obtaining multiple ratings of affective experience over time. The traditional method of collecting such data is to utilize either paper-and-pencil (PP) or electronic (personal digital assistants; PDA) diaries (Bolger, Davis, & Rafaeli, 2003).

The current studies introduced an alternative daily-diary medium: cell-phone text-messaging. Cell-phones have been used previously to collect experience sampling data, relying on either automated voice-recording or software (Collins, Kashdan, & Gollnisch, 2003; Kauer, Reid, Sancu, & Patton, 2009; Modi & Quittner, 2006; Reid et al., 2008) and free-response text-messages (Anhoj & Moldrup, 2004; Kuntsche & Robert, 2009). In our studies, we relied on Simple Mail Transfer Protocol (SMTP); we used a secure e-mail address to send reminder text-messages to

participants, and participants simply responded to the secure e-mail via a text-message. We believe that this method has many advantages. Participants receive reminders when it is time to complete a diary entry, decreasing the probability of non-compliance. Each response is time-stamped, ensuring that participants do not fabricate the response time and allowing for examinations of response latency. Data are available to the researchers in real-time. As a result, we have some ability to monitor whether participants adhere to proper procedure, which could allow for intervention and correction of errors. Participants are also able to travel at no detriment to the study. Participants who may leave town before the conclusion of the study are able to generate data available at the same time as local participants. Completing the diary entries is discreet, as it appears that the participant is sending an ordinary text message; this may reduce the likelihood of non-compliance due to embarrassment. Sending text-messages from a secure e-mail address to participants is free. Additionally, because participants provide their own phones, the lab incurs no additional cost if phones are lost or broken. Perhaps most importantly, this method takes advantage of a routine and common activity for many people, potentially increasing participants' level of comfort with the study procedures. Potential limitations of text-messaging are that messages are limited to 160 characters, it may not be employed as easily with the very young or very elderly, and it would be difficult to implement in populations without widespread access to mobile networks (Kuntsche & Robert, 2009). The current studies employed cell-phone text-messaging to examine individual differences in the experience of mixed emotions.

6. Study 1

6.1. Methods

6.1.1. Participants

Participants were fifty Northwestern University undergraduates (40 female) who were recruited from fliers posted on campus, e-mails to class rosters, and advertisements on a paid subject pool website. Participants were compensated for their text messaging expenses and received up to \$60 based on the number of complete text message responses. All methods were approved by the Northwestern University IRB.

6.1.2. Procedure

Participants who filled out an online questionnaire were contacted by a researcher and invited to attend an information session. At the information session, participants received a 6.4 cm × 8.9 cm picture-frame key chain, inside of which was a double-sided sheet of paper containing items assessing affect and perceptions of situations.² Participants received training on how to respond to the items on the card using cell-phone text-messaging, and each participant was able to send a correctly completed practice response before beginning the actual study.

Six times per day (9 A.M., 12 P.M., 3 P.M., 6 P.M., 9 P.M., 12 A.M.) for two weeks, participants received a text message (automatically sent from a secure-email account using applescript) requesting that they respond to the items on their key chain. Because cell-phone text-messaging is a new method for collecting experiential data, fixed schedules were chosen to increase the ease with which participants could comply with the procedure. Although pseudo-random sampling allows for more comprehensive coverage of the day, participants routinely report that responding to fixed schedules is much easier and avoids such annoyances as constantly

² Cards also included additional items that were not relevant to this particular study. A total of 44 items were presented on the card.

Table 1

Descriptive statistics for text-messaging reports. The first two columns show item means and standard deviations calculated across all reports. The next three columns show statistics aggregated across participants: the mean of each state aggregated by participant; between-person standard deviations (BP *SD*); and pooled within-person standard deviations (WP *SD*). The *ICC1* is the amount of variance of an individual score that is attributable to between-person variance. The *ICC2* represents the reliability of between-person means.

Variable	All reports		Aggregated across participants			Intraclass correlations	
	<i>M</i>	<i>SD</i>	<i>M</i>	BP <i>SD</i>	WP <i>SD</i>	<i>ICC1</i>	<i>ICC2</i>
Energetic arousal	3.99	1.08	3.96	0.51	0.98	.19	.94
Tense arousal	2.55	1.04	2.62	0.66	0.82	.38	.98
Pleasant affect	3.91	1.09	3.86	0.68	0.87	.37	.98
Unpleasant affect	1.85	0.98	1.88	0.59	0.81	.32	.97
Threat appraisals	1.49	0.69	1.52	0.43	0.57	.32	.97
Incentive appraisals	3.20	1.04	3.18	0.53	0.93	.21	.95

checking the phone to make sure that they had not missed a survey (Klasnja et al., 2008). Each cell-phone carrier has a unique email suffix that enables a person to send a text message to someone via an email account. For example, to send an email to a person whose phone number is (555)-444-3333 and who uses the phone carrier Verizon Wireless, one would type the text message itself in the body of an email and send the email to the address 5554443333@vtext.com. Participants replied by sending a text message to the secure e-mail account containing a string of numbers, one corresponding to each adjective printed on the key chain. To complete a diary entry, a participant sent a text message indicating how well each adjective described him or her on a scale of 1 (“not at all”) to 6 (“very well”). For example, if the adjectives “energetic”, “tense”, and “Pleasant”, and “Unpleasant” occurred in that order, the number string “6134” may be an appropriate response for a participant feeling very energetic, not at all tense, somewhat Pleasant, and moderately Unpleasant.

The response-rate was similar to that of traditional experience-sampling studies (Conner, Barrett, Tugade, & Tennen, 2007). Of the possible 84 reports per participant, the mean was 69.7 (83%) reports (*SD* = 24.4), and the median was 74.5 (89(*MAD* = 17.05). Forty-two (36 female) participants generated data that were retained for analyses. Eight participants were excluded from data analyses for the following reasons: low rate of response (less than two responses per day, *n* = 4); no variability in responses (suggesting that they simply forwarded the same response each time, *n* = 3); and consistently responding to less than the number of items included on the text-message assessment *n* = 1. Response rates were relatively uniform across time, ranging from 401 responses to the text sent at 12 A.M. and 492 to the reminder sent at 12 P.M. The median response latency was 33 min, which is likely a longer latency to respond compared with traditional beeper methods. Because we were concerned with the relationships between states rather than time effects, we did not exclude responses based on latency to respond.

6.1.3. Materials

6.1.3.1. Affect and situation appraisals. Participants responded to the prompt, “How are you feeling right now?” on a scale from 1 (“not at all”) to 6 (“very well”) indicating how well the following adjectives described his or her current affective state. Items from the Motivation States Questionnaire (MSQ) (Revelle & Anderson, 1996) that previously showed the highest loadings on the dimensions of EA, TA, and valence (separated into Pleasant/Unpleasant affects) (Rafaeli & Revelle, 2006) were selected to assess each affective variable: EA – “energetic”, “alert”, and “sluggish” (reverse-scored); TA – “calm” (reverse-scored), “relaxed” (reverse-scored), and “tense”; Pleasant affect – “confident”, “cheerful”, and “pleased”; and Unpleasant affect – “grouchy”, “irritable”, and “gloomy”. Participants responded to the prompt, “Over the past 30 min, the situation I was in was...”, on a scale from 1 (“not at

all”) to 6 (“very well”) indicating how well the following adjectives described his or her situation appraisal. Appraisals of threat were assessed with the adjectives “threatening”, “risky”, and “negative”. Appraisals of a potentially rewarding incentive were assessed with the adjectives “challenging”, “rewarding”, and “positive”.

7. Results

7.1. Descriptive statistics

7.1.1. Text-messaging reports

For a preliminary look at the nature of the diary recordings of affect and situation appraisals, we computed the mean and standard deviation across all reports (Table 1). The mean in column 1 represents a variable’s aggregate item mean calculated across all reports, and the standard deviation in column 2 represents how much variation there was across all reports (*N* = 2787). The variability across all reports can be conceptualized as total variability. Total variability may be partitioned into between-person variability and within-person variability; that is, variability across all reports is due to participants varying from each other (between-person variability) and over time (within-person variability). Between-person variability is represented as the variability between participants’ average values for each respective variable. Column 3 shows the average value for each variable across participants (*M*), and column 4 represents the between-person variability (*SD*) in each variable. The second source of total variability is within-person variability – variability within each individual participant’s reports. Whereas between-person variability (column 4) represents variation among participant means, within-person variability represents each participant’s variation from his or her own mean. Column 5 represents within-person variability as the pooled standard deviation for each variable.

The amount of variance in individual reports that is due to between-person differences is represented by the intraclass correlation 1 (*ICC1*, Shrout & Fleiss, 1979) in column 6. These values ranged from .19 to .38, indicating that the amount of variance in individual reports due to within-person variations ranged from 81% to 62%. The high intraclass correlation 2 (*ICC2*, (Shrout & Fleiss, 1979)) statistics show that participant means may be reliably differentiated from each other. In summary, the total variance of affect and situations may be decomposed into variance due to trait like effects (between-person differences) and that due to state like effects (within-person differences). Although the amount of within-person variance is relatively greater than the amount of between-person variance, high *ICC2* values indicate that between-person variations are stable and meaningful.³ We are interested

³ Minimum and maximum values for each state are at or very near the minimum and maximum of each respective scale, and minimums and maximums of aggregated variables are relatively less extreme (i.e., rather than from varying from 1 to 6 as states do, they range from about 1.5 to 4.5).

in examining within-person variations in affect as well as between-person differences in within-person associations among affects and situation appraisals.

7.2. Analytic strategy for examining within-person associations

Analyses were done in R (R Development Core Team, 2009) using the *multilevel* (Bliese, 2009), and *nlme* Pinheiro, Bates, DebRoy, & Sarkar (2009), and *psych* (Revelle, 2011) packages. We used multilevel modeling (MLM, also known as hierarchical linear modeling) as our main analytic technique. MLM, as its name suggests, analyzes data at multiple levels; this is important for the current data because observations were nested within individuals.

7.3. What is the range of within-person associations between EA and TA, and between Pleasant and Unpleasant affects?

Rafaeli et al. (2007) found that the within-person associations between EA and TA ranged from de-synchrony to synchrony. We attempted to replicate this finding as well as examine the within-person associations between Pleasant and Unpleasant affects.

We first needed to evaluate whether there were individual differences in within-person relationships between EA and TA, and in the relationships between Pleasant and Unpleasant affects. We did this by comparing a model constraining the slope between EA and TA to be fixed across individuals (fixed effects model) versus a model allowing the slope between EA and TA to vary across individuals (random effects model). The fixed effects model predicting EA from TA was specified following the terminology of Bryk & Raudenbush (1992).

$$EA_{ij} = \beta_{0i} + \beta_{1i}TA_{ij} + r_{ij} \quad (1)$$

$$\beta_{0i} = \gamma_{00} + \mu_{0i} \quad (2)$$

$$\beta_{1i} = \gamma_{10} \quad (3)$$

Eq. (1) states that the energetic arousal score for individual *i* on occasion *j* (EA_{ij}) is a function of the individual's intercept, β_{0i} , a component reflecting the relationship between EA and TA, $\beta_{1i}TA_{ij}$, and a term that reflects between-person error, r_{ij} . TA was mean-centered around each individual's mean; therefore the intercept term reflects an individual's mean level of EA. Eq. (2) states that each individual's intercept is a function of a common intercept, γ_{00} , and an error term that indicates that the intercept is allowed to vary across individuals, μ_{0i} . Eq. (3) states that the slope between EA and TA is fixed across individuals; that is, the slope relating EA to TA is specified to be identical for each individual. The three rows may be combined into a single equation as follows:

$$EA_{ij} = \gamma_{00} + \mu_{0i} + \gamma_{10}TA_{ij} + r_{ij} \quad (4)$$

Eq. (4) may be compared to the random effects model (5) allowing the slope between EA and TA to vary across individuals.

$$EA_{ij} = \gamma_{00} + u_{0i} + \gamma_{10}TA_{ij} + u_{1i}TA_{ij} + r_{ij} \quad (5)$$

The additional term in Eq. (5), $u_{1i}TA_{ij}$, indicates that slopes between TA and EA were allowed to vary across participants.

The log likelihood values for each model were compared; if there is significant variation in the relationships between variables, the model allowing slopes to vary across individuals should fit the data significantly better than the fixed slopes model. This strategy was employed to evaluate whether the relationships between EA and TA varied across participants, and whether the relationships between Pleasant and Unpleasant affects varied across participants. One MLMs predicted EA from TA and another MLM predicted Pleasant affect from Unpleasant affect. In each case, the model allowing slopes to vary across participants fit the data better than the corresponding fixed model: for EA–TA, $L.ratio_{df=2} = 87.84$,

$p < .001$; Pleasant affect–Unpleasant affect, $L.ratio_{df=2} = 60.90$, $p < .001$.

Next, we examined the range of associations between affects of opposite valence. In the interest of space and clarity, we present results from MLMs from here on by referring to unstandardized (b) coefficient values rather than presenting the entire MLM equation. Unstandardized (b) coefficients reveal the association between affects for the typical individual. Importantly, replicating (Rafaeli et al., 2007), the relationship between EA and TA ranged from strong de-synchrony ($b = -.85$) to weak synchrony ($b = .26$), whereas the relationship between Pleasant and Unpleasant affect ranged from strong de-synchrony ($b = -1.17$) to weak de-synchrony ($b = -.17$). The fixed effects from MLMs also showed that, similar to Rafaeli et al. (2007), EA was slightly, negatively related to TA on average $b = -.26$, $p < .001$. In contrast, Pleasant affect showed a strong negative relationship with Unpleasant affect, $b = -.64$, $p < .001$.

7.4. Predicting individual differences in within-person relationships between ea and ta, and between Pleasantness and Unpleasantness: exploring affective synchrony

We predicted that individual differences in affective synchrony should be related to individual differences in the tendency to perceive threats as potentially rewarding challenges, or incentives. However, before examining this prediction, we first needed to determine whether the within-person variation in the relationships between Threat and Incentive appraisals differed across individuals. Our analysis strategy was the same as for examining whether the relationships between affective variables differed across participants.

The MLM model allowing the slope between Threat and Incentive to vary across participants fit the data better than the corresponding fixed model, $L.ratio_{df=2} = 38.25$, $p < .001$, suggesting that there were reliable individual differences in the within-person relationships between Threat appraisals and Incentive appraisals.

To evaluate whether synchrony was related to perceiving threats as incentive, we next needed to operationalize individual differences in each participant's association between Threat appraisals and Incentive appraisals. We accomplished this by finding each participant's correlation between perceptions of Threat and Incentive ($r_M = 0.06$, $r_{SD} = 0.25$, $range = -.52$ to $.46$). Related to our hypotheses, the individual with a $-.52$ correlation typically views threats as the absence of incentive, whereas the individual with the $.46$ correlation sees threat and incentive as typically occurring together. These correlations were used as predictors of individual differences in EA–TA relationships and Pleasantness–Unpleasantness relationships in the following MLMs. Using correlations as predictors means that it is the relationship between two variables that will be used as a predictor rather than the absolute standing on any one variable.⁴

We conducted one MLM predicting EA from TA, the correlation between perceptions of Threats and Incentives, and the cross-level interaction of predictor variables simultaneously. Individuals who routinely perceive threats as incentives had more positive relationships between EA and TA, as indicated by the positive and significant cross-level interaction term ($b = .39$, $p < .05$). A separate MLM predicted Pleasantness from Unpleasantness the correlation between perceptions of Threats and Incentives, and the cross-level interaction of predictor variables simultaneously. The Pleasant–Unpleasant relationship was not related to the correlation between perceptions of Threat and Incentive ($b = .10$, $p < .54$). These analyses suggest that

⁴ We also conducted MLMs using the absolute standing on situational appraisals of risk and challenge as moderator variables between but did not find that these variables predicted synchrony.

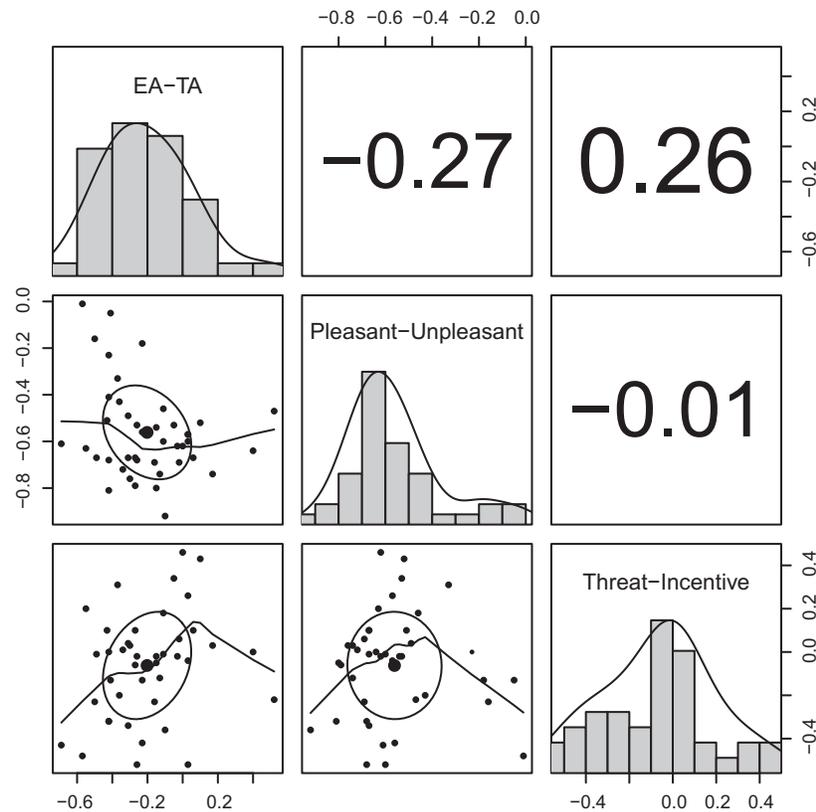


Fig. 1. The diagonal shows histograms of the within-subject relationships (correlations) between variables. The between-subjects relationships of within-subject associations are shown below the diagonal as scatter plots and above the diagonal as Pearson correlations. For example, the between-subjects relationship between within-person EA–TA associations and within-person Pleasant–Unpleasant associations is shown as a scatter plot in the second row of the first column and as a correlation in the first row of the second column. The best fitting LOESS regression and the 1 SD correlational ellipse are shown. LOESS is a robust smoother based on local polynomial regression.

the EA–TA relationship was specifically related to perceiving Threats as Incentives. Results are depicted graphically in Fig. 1.⁵

7.5. Discussion: Study 1

The first goal of this research was to determine which dimensions of positive and negative affectivity may occur together. Study 1 replicated *Rafaeli et al. (2007)* by showing that the within-person relationships between EA and TA ranged from strong de-synchrony to moderate synchrony, however, the within-person relationships between Pleasant and Unpleasant affect ranged only from de-synchrony to asynchrony. The second goal was to examine some of the factors that may account for individual differences in affective synchrony. EA–TA synchrony was related to the contingency between Threat and Incentive appraisals; however, the Pleasant–Unpleasant relationship was unrelated to this contingency.

8. Study 2

Study 2 builds upon Study 1 in a number of ways. First, the measurements of EA and TA in Study 1 included adjectives with both positive and negative connotations, raising the possibility that EA–TA synchrony resulted due to a valence overlap between oper-

ationalizations of EA and TA. To evaluate this possibility, Study 2 assesses EA with positive adjectives only and TA with negative adjectives only. We also assess Pleasant affect with positive valence adjectives and Unpleasant affect with negative valence adjectives.

Second, our measure of an Incentive appraisal was operationalized as the aggregate of perceiving a situation as challenging, rewarding, and positive in an effort to match Thayer's definition of a challenge with the possibility for a pleasing outcome; however, it is possible that challenge appraisals and incentive appraisals relate differentially to EA and TA. We attempt to separate these effects in Study 2 by analyzing appraisals of challenging and pleasing situations separately.

Third, we explored individual difference variables as potential predictors of synchrony. Keeping in line with the notion presented in *Rafaeli et al. (2007)*, we selected variables that are thought to be broadly related to positive and negative emotional experience and emotional reactivity. Specifically, we examine whether measures of affective traits (EA, TA, Pleasantness, and Unpleasantness) are related to synchrony.

Finally, whereas the participants in Study 1 were all university students, Study 2 obtained a mixed sample of university students and community adults.

8.1. Method

8.1.1. Participants and procedure

Participants were 49 individuals (36 female) who were recruited from advertisements on a paid subject pool website and

⁵ Although the locally smooth regression relationship between within-person associations in EA–TA and within-person associations in Pleasant–Unpleasant affects appears to be quadratic, the *b* from the MLM testing for a quadratic relationship was not statistically significant.

Table 2

Study 2: Descriptive statistics for text-messaging reports. The first two columns show means and standard deviations calculated across all reports. The next three columns show statistics aggregated across participants: the mean of each state aggregated by participant; between-person standard deviations (BP SD); and pooled within-person standard deviations (WP SD). The ICC1 is the amount of variance of an individual score that is attributable to between-person variance. The ICC2 represents the reliability of between-person means.

Variable	All reports		Aggregated across participants			Intraclass correlations	
	M	SD	M	BP SD	WP SD	ICC1	ICC2
Energetic arousal	2.43	1.10	2.48	0.77	0.80	.50	.98
Tense arousal	2.23	0.89	2.26	0.58	0.69	.43	.98
Pleasantness	3.32	1.14	3.42	0.80	0.80	.53	.98
Unpleasantness	1.85	0.99	1.87	0.50	0.87	.28	.96
Threat appraisals	1.47	0.91	1.47	0.57	0.78	.42	.98
Challenge appraisals	2.20	1.34	2.25	0.57	1.26	.18	.92
Pleasant appraisals	2.84	1.50	2.87	0.83	1.28	.32	.96

on websites listing part-time job opportunities in the greater Chicago area. Forty (29 female) participants generated data that met criteria for being retained for data analyses: participants were excluded for having an unacceptable number of reports ($n = 5$), no variability in responses ($n = 3$), and incomplete reports ($n = 1$). Of these 40, 21 were university students and 19 were adults living in the greater Chicago area. Participants came to the lab to attend an information session and complete training in text-messaging methodology.⁶ Participants sent text-message responses to a secure e-mail address 6 times per day (9 A.M., 12 P.M., 3 P.M., 6 P.M., 9 P.M., 12 A.M.) for two weeks. Participants were compensated for their texting expenses and up to an additional \$50 based on their number of complete text message responses. Of the possible 84 reports per participant, the mean was 55.7 (66%) reports ($SD = 23.7$), and the median was 60 (71%) reports ($MAD = 26.7$). Response rates were relatively uniform across time, ranging from 320 responses to the text sent at 12 A.M. and 419 to the reminder sent at 3 P.M. The median response latency was 39 min. Rates of completion were slightly lower than in Study 1, and latency to respond was slightly longer. It is interesting to note that the decreased rate of response and increased response latency paralleled the reduction in compensation from Study 1 (\$60 to \$50), suggesting that compensation may affect motivation to respond.

8.2. Materials

8.2.1. Affect and situation appraisals

As in Study 1, EA and TA were assessed with items from the MSQ that previously loaded highly on each respective dimension (Rafaeli & Revelle, 2006). Participants responded to the prompt, "How are you feeling right now?" on a scale from 1 ("not at all") to 6 ("very well") indicating how well the following adjectives described his or her current affective state. EA was assessed with four adjectives with positive connotations: "excited", "lively", "full-of-pep", and "vigorous"; TA was measured with four adjectives with negative connotations: "distressed", "jittery", "nervous", and "stirred-up"; Pleasantness was assessed with two adjectives with positive connotations: "happy", and "strong"; and Unpleasantness was assessed with two adjectives with negative connotations: "irritable", "upset".⁷ For situation appraisals, participants responded to the prompt, "Over the past 30 min, the situation I was in was...", on a scale from 1 ("not at all") to 6 ("very well") indicating how well the following adjectives described his or her situation appraisal. Appraisals of threat were assessed with the

adjective "threatening," challenge appraisals were assessed with the adjective "challenging," and pleasing appraisals were assessed with the adjective "pleasing."

8.2.2. Trait measures of energetic arousal and tense arousal, Pleasantness, and Unpleasantness

Participants were asked to rate affective adjectives from the MSQ reflecting each respective dimension based on how they feel in general ("In general, I feel..."). Varying the time-frame of instructions for ratings of affect has been used extensively to create reliable and valid measures of affect (Watson, 2000). Cronbach's α reliabilities were: for trait EA ($n = 4$), $\alpha = .88$; trait TA ($n = 4$), $\alpha = .63$; trait Pleasantness, $\alpha = .72$; and trait Unpleasantness ($n = 2$), $\alpha = .40$.

8.3. Results and discussion

8.3.1. Descriptive statistics

As in Study 1, we characterized reports of affect and situation appraisals by their overall item averages and variabilities, between-person averages and standard deviations, within-person standard deviations, the amount of variance in each report that was attributable to between-person variation, and the reliability of between-person variations (Table 2).⁸ It is important that variables showed both sizable between-person variability and within-person variability, and that between-person differences were reliable for each variable. The percentage of variance attributable to between-person and within-person variability differed across studies; examining the factors that may be responsible for such variation is left for future research. Means and standard deviations for affective traits were: for EA ($M = 3.95$, $SD = 1.07$); TA ($M = 2.49$, $SD = 0.70$); Pleasantness ($M = 4.47$, $SD = 0.91$); for EA ($M = 2.48$, $SD = 0.84$);

8.4. Individual differences in EA–TA and Pleasantness–Unpleasantness relationships

As in Study 1, we compared two MLMs predicting EA from TA, fixing the slope between variables across individuals in one model and allowing the slope to vary across individuals in the other model. The within-person relationship between EA and TA varied significantly across individuals, as the MLM allowing slopes to vary across participants fit the data better than the corresponding fixed model, $Lratio_{df=2} = 141.67$, $p < .001$. Replicating Study 1, the relationship between EA and TA ranged from de-synchrony ($b = -.99$) to synchrony ($b = .45$), suggesting that synchrony ob-

⁶ As in Study 1, text-messaging cards contained items assessing affects and situations as well as additional items that were relevant to the current study. A total of 50 items appeared on the card.

⁷ Although we would have ideally liked to include more adjectives assessing Pleasantness and Unpleasantness, there are relatively few adjectives that may be used to assess this dimension that do not have high EA or TA content.

⁸ As in Study 1, minimum and maximum values for each state were at or very near the minimum and maximum of each respective scale, and minimums and maximums of aggregated variables are relatively less extreme.

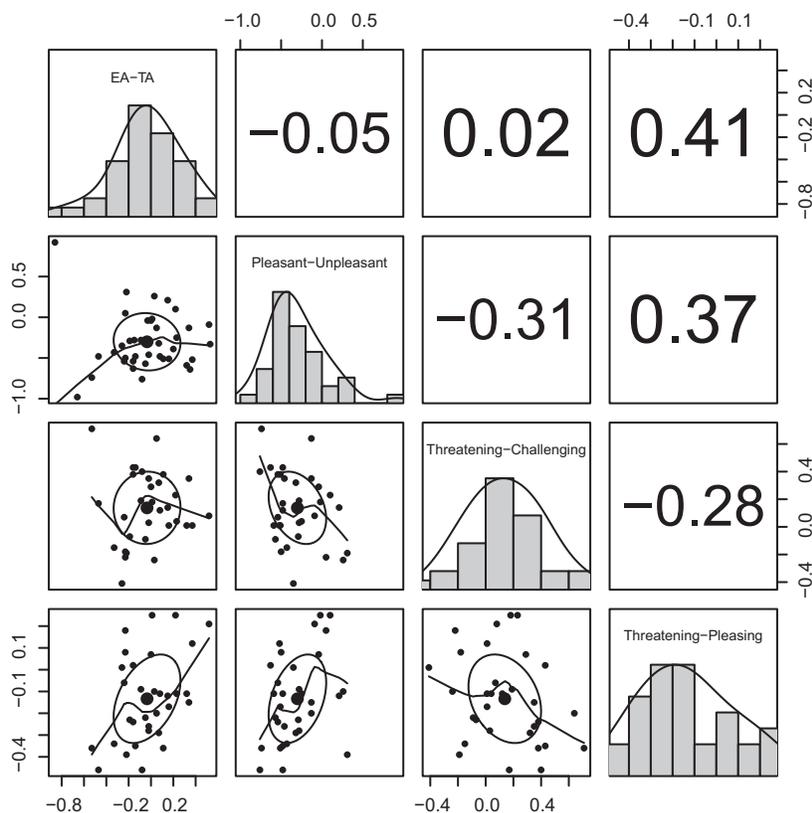


Fig. 2. The diagonal shows histograms of the within-subject relationships between variables. The between-subjects relationships of within-subject associations are shown below the diagonal as scatter plots and above the diagonal as correlations. For example, the between-subjects relationship between within-person EA–TA associations and within-person Reward–Threat associations is shown as a scatter plot in the second row of the first column and as a correlation in the first row of the second column. The best fitting LOESS regression and the 1 SD correlational ellipse are shown. LOESS is a robust smoother based on local polynomial regression.

served in Study 1 and in [Rafaeli et al. \(2007\)](#) was not due simply to a valence overlap between EA and TA operationalizations. Within the typical individual, EA was slightly negatively related to TA $b = -.10$, $SD = 0.48$. The within-person relationship between Pleasant and Unpleasant affect also varied across individuals; the MLM allowing slopes to vary across participants fit the data better than the corresponding fixed model, $Lratio_{df=2} = 187.87$, $p < .001$. The relationship between Pleasantness and Unpleasantness ranged from de-synchrony ($b = -1.09$) to synchrony ($b = .22$); however, only five individuals had relationships above $b = 0$ and only one individual had a relationship of greater than $b = .13$. The typical individual had a de-synchronous relationship between Pleasantness and Unpleasantness $b = -.27$, $SD = .24$.

8.5. Predicting synchrony

Study 1 revealed that individual differences in within-person EA–TA (but not Pleasant–Unpleasant relationships) were related to individual differences in threat–incentive contingencies. In study 2, we attempted to separate the components of incentive appraisals into challenging and pleasing aspects. Thus, our predictors of synchrony in this study were participants' within-person relationships between Threat appraisals and Challenge appraisals, and participants' within-person relationships between Threat appraisals and Pleasing appraisals. Comparisons of fixed-slope MLMs with random-slope MLMs showed that there was significant within-person variation in the relationships between threatening and

challenging appraisals, $Lratio_{df=2} = 46.25$, $p < .001$, and between threatening and pleasing appraisals, $Lratio_{df=2} = 39.50$, $p < .001$.

Individual differences in within-person relationships between situation appraisals were operationalized as each participant's correlation between appraisals of threatening and challenging situations ($r_M = 0.14$, $r_{SD} = 0.26$, $range = -.41$ to $.71$) and between threatening and pleasing situations ($r_M = -0.13$, $r_{SD} = 0.20$, $range = -0.46$ to 0.25). These correlations were used as predictors of individual differences in EA–TA relationships in the following MLMs.

MLM cross-level interaction coefficients showed that individual differences in threatening–challenging contingencies were not associated with EA–TA synchrony ($b = 0.04$, $p = .85$), whereas individual differences in threatening–pleasing contingencies were positively related to EA–TA synchrony ($b = 0.49$, $p < .05$). These analyses suggest that the EA–TA relationship is specifically related to perceiving threatening and pleasing situations as occurring together (see Fig. 2).⁹ We found the same pattern of results when predicting the Pleasant–Unpleasant relationship from contingencies of situation appraisals. Individual differences in threatening–challenging contingencies were not significantly associated to Pleasant–Unpleasant relationships ($b = -0.24$, $p = .20$), whereas individual differences in threatening–pleasing contingencies were positively related to Pleasant–Unpleasant relationships ($b = 0.49$, $p < .05$).

⁹ Absolute standing on situational appraisals of threat, challenge, and reward did not predict synchrony.

8.6. Affective traits as predictors of affective synchrony

Rafaeli et al. (2007) analyzed each affective trait as a predictor of the EA–TA relationship individually but did not find any significant main effects. In our analyses, we consider the possibility that both main effects and interactions of affective traits may predict EA–TA and Pleasant–Unpleasant relationships. Thus, we conducted MLMs predicting the both the EA–TA relationship and Pleasant–

Unpleasantness relationship from (1) trait EA, TA, and the interaction of those variables, and (2) trait Pleasantness, trait Unpleasantness, and their interaction. For example, when predicting the EA–TA relationship from affective traits, analyses were done by conducting a MLM predicting state EA from state TA, trait EA, trait TA, each two-way interaction term (state TA*trait EA, state TA*trait TA, and trait EA*trait TA), and a three-way interaction term (state TA*trait EA*trait TA). Across analyses, significant

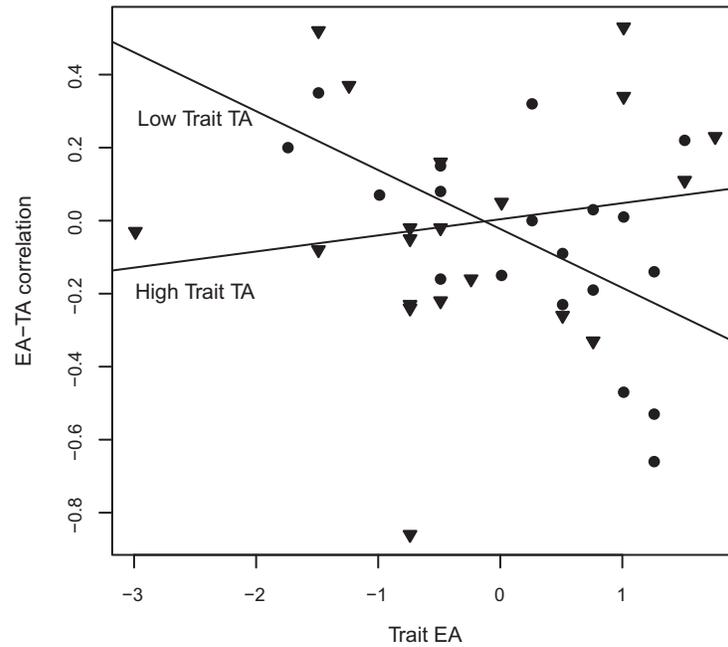


Fig. 3. The relationship between EA and TA varies as a function of individuals' relationships between trait EA and trait TA. Individuals with lower levels of trait TA (circles) experience EA and TA more synchronously at lower levels of trait EA, whereas individuals with higher levels of trait TA (triangles) experience affect more synchronously at higher levels of trait EA.

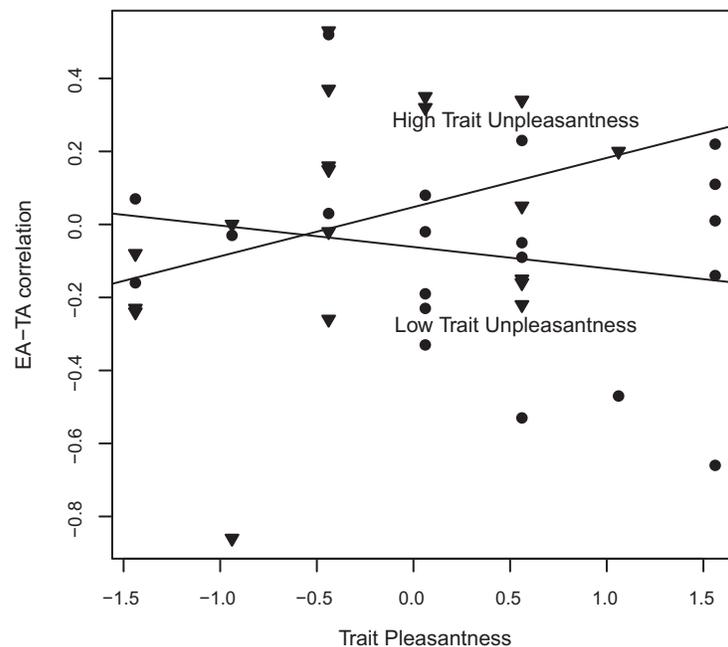


Fig. 4. The relationship between EA and TA varies as a function of individuals' relationships between trait Pleasantness and trait Unpleasantness. Individuals with lower levels of trait Unpleasantness (circles) experience EA and TA more synchronously at lower levels of trait Pleasantness, whereas individuals with higher levels of trait Unpleasantness (triangles) experience affect more synchronously at higher levels of trait Pleasantness.

predictors of the EA–TA relationship were trait EA ($b = -0.16$, $p < .05$), the interaction between trait EA and trait TA ($b = 0.39$, $p < .001$), and the interaction between trait Pleasantness and trait Unpleasantness ($b = 0.31$, $p < .01$); the relationship between Pleasant and Unpleasant affect was not significantly predicted by any term entered in the MLMs. Figs. 3 and 4 illustrate the relationships between the EA–TA correlation and trait affect. What is striking is that trait positive affects (EA and Pleasantness) predict the within-person correlation between EA and TA differently depending on trait levels of negative affects (TA and Unpleasantness). For individuals with higher levels of trait negative affects, EA and TA becomes more positive as trait positive affects increase.

9. General discussion

The goal of this paper was to examine two important issues for the study of individual differences in affective synchrony. The first issue was to determine which positive and negative affects may be felt synchronously. The second issue was to determine whether individual differences in the relationships between positive affects and negative affects varied as a function of situational appraisals, as suggested by the dynamic affect model of Zautra and colleagues (Zautra et al., 2002; Zautra, 2003) as well as Thayer's (1989) models of affect.

In regard to our first goal, we replicated previous research (Rafaeli et al., 2007) by finding that within-person associations between EA and TA ranged from de-synchrony to synchrony. In contrast, we found that associations between Pleasant and Unpleasant affects ranged from de-synchrony to asynchrony.

In regard to our second goal, we determined in Study 1 that within-person EA–TA relationships were predicted by more positive associations between incentive and threat appraisals. In Study 2, we decomposed incentive appraisals into perceptions of challenging and pleasing situations and found that within-person EA–TA relationships as well as Pleasant–Unpleasant relationships were predicted specifically by more positive associations between pleasing appraisals and threat appraisals. The null findings for the threat–challenge contingency may reflect that threats that are perceived as challenges may sometimes engage both approach and avoidance processes but other times may only engage avoidance processes if the challenge is judged to be too difficult. For example, many students taking an advanced physics course may perceive the course as threatening (to their grade point average) as well as challenging. Some students might accept the challenge and study arduously, whereas others may perceive the challenge of learning the material to be too difficult and thus refrain from studying. In contrast, threatening situations that are also routinely perceived as rewarding, positive, and pleasing (e.g., gambling in a casino) might more reliably be related to both avoidance and approach processes.

A challenge to the findings relating synchrony to situational contingencies is the argument that correlations between affects and correlations between situational appraisals are isomorphic constructs and thus that relationships between those constructs are not meaningful. There are empirical and theoretical reasons to conceptualize such variables as distinct constructs. Empirically, it might be expected that the relationships between isomorphic constructs would be much higher than the modest relationships found in this study. Theoretically, affective and cognitive components are typically seen as distinct and fundamental building blocks for personality (Allport, 1937; Emmons, 1989; Hilgard, 1980; Johnson, 1997; Pytlik Zillig, Hemenover, & Dienstbier, 2002; Winter, John, Stewart, Klohnen, & Duncan, 1998). Indeed, we have previously put forth a framework for organizing personality according to four distinct modes of effective functioning – Af-

fect (A), Behavior (B), Cognition (C), and Desire (D) – the ABCDs of personality (Ortony, Norman, & Revelle, 2005; Wilt & Revelle, 2009). From this view, the current studies first sought to examine the cognitive (C) factors that influence individual differences in an affective (A) variable, affective synchrony. Nonetheless, the answer to the question of whether synchrony and correlations between situation appraisals are distinct constructs will need to come from experimental rather than correlational designs. Future studies may attempt to devise manipulations that could have separate effects on the affects and cognitions included in this study in order to answer this question.

Apart from their substantive contribution, the findings from these studies are also important in that they provide an initial validation of using cell-phone text-messaging as a method for collecting experiential data. Future research may extend this method to other psychology studies when short or multiple-choice responses are desired. It is important to note that research requiring a short latency between reminders to respond and responses may want to implement a procedure that decreases response latency (e.g., higher compensation for quicker responses).

9.1. Associations between positivity and negativity from an approach-avoidance systems perspective

This was the first research to investigate individual differences in the within-person relationships between Pleasantness and Unpleasantness. The range of associations between those affects ranged from de-synchrony (negative associations) to asynchrony (no association). This result contrasts with the consistent finding that associations between EA and TA range from de-synchrony to synchrony (positive association). Why do some individuals experience EA–TA synchrony whereas no individuals experience Pleasantness–Unpleasantness synchrony? One potential explanation was that the EA–TA synchrony finding in Rafaeli et al. (2007) and in Study 1 in the current paper were artifacts resulting from measuring both EA and TA with positively and negatively valenced adjectives. However, Study 2 showed that EA–TA synchrony remained even when EA was measured with positive adjectives only and TA was measured with negative adjectives only.

We believe that a close consideration of the systems and processes thought to produce EA, TA, Pleasantness, and Unpleasantness may illuminate the question of which affects have a synchronous relationship. It is widely accepted that affects are tied to independent approach and avoidance motivation systems (Carver & White, 1994; Davidson, 1992; Depue & Collins, 1999; Gray, 1994; Fowles, 1987; Smillie, Loxton, & Avery, in press). The affects included in this study may be mapped in approach/avoidance space. EA is thought to be related to approach processes only, and TA to avoidance processes only (Schimmack & Grob, 2000; Thayer, 1989); therefore, the finding that the associations between EA and TA range from negative to positive suggests that it is possible for the typically independent approach and avoidance systems to be flexibly coactivated.

In contrast to the conceptualization of EA as arising from an approach system and TA from an avoidance system, it has been proposed that the Pleasant and Unpleasant affects are derived from an approach system only (Carver & Harmon-Jones, 2009). In Carver & Harmon-Jones (2009)'s model, approach-related affects are conceptualized on a continuum: the positive pole of the continuum is defined by Pleasant affects such as cheerfulness and confidence and at the negative pole Unpleasant affects such as grouchiness and irritability. Pleasantness is thought to arise from doing well at approach-related tasks whereas Unpleasantness is thought to arise from doing poorly at approach-related tasks (Carver & Scheier, 2000; Carver, 2001). From this perspective, it stands to reason that when individuals are succeeding at approach-related

tasks (which produces Pleasantness), they are not typically simultaneously failing at those same tasks. Thus, mapping Pleasantness and Unpleasantness in approach/avoidance space provides a compelling explanation for why the within-person relationships between Pleasantness and Unpleasantness do not typically occur in synchronous fashion. Avoidance affects in Carver & Harmon-Jones (2009)'s model are defined at the negative pole by affects such as fear and anxiety and at the positive pole by affects such as relief and calm. Negative avoidance affects are thought to be generated by doing poorly at avoidance tasks whereas positive avoidance affects are thought to be generated by doing well at avoidance tasks. In regards to our current findings, we propose that positive and negative affects arising from separate motivational systems may show synchronous relationships for some individuals because independent motivational systems may be flexibly coactivated; however, positive and negative adjectives arising from the same motivational systems should not show synchronous relationships because they lie at opposite ends of a unipolar affective dimension. Future research may confirm or reject this hypothesis by examining individual differences in the relationships between a wider variety of affective adjectives.

The approach-avoidance systems framework described above is a compelling perspective from which to interpret the relationships between EA–TA synchrony and situational contingencies. From an approach-avoidance systems context, de-synchrony occurs when one system is dominant or suppresses the other system; asynchrony occurs when there is no competition between approach and avoidance systems; and synchrony when approach and avoidance systems are coactivated and are thus in conflict. Applying these ideas the observed associations between within-person EA–TA relationships and situational contingencies results in the following straightforward interpretations: more negative associations between threatening and incentive/pleasing appraisals might reflect the suppression of one system by the other; independent relationships between those appraisals may reflect an absence of competition between systems, and more positive relationships among situations might reflect conflict between approach and avoidance. These findings are in line with Thayer's (1989) original idea that cognitive appraisals may influence the degree of coactivation between affective systems. Specifically, our findings are consistent with Thayer's notion that positive and negative affects may be positively correlated when threats (activating the avoidance system) are perceived as potential rewards (activating the approach system). Thayer's hypothesis was specific to situational differences in correlations between affects rather than individual differences in typical within-person correlations. Our findings go beyond Thayer that individual differences in one's typical relationships between affects of opposite valence would be dependent on their typical appraisals of situations.

The approach-avoidance perspective may also explain why affective traits interacted to predict synchrony. We found that individuals with extreme and dissimilar levels of affective traits (e.g., high EA, low TA) had more de-synchronous EA–TA relationships, whereas individuals with extreme and similar levels of affective traits (e.g., high EA, high TA) had more synchronous EA–TA relationships. Dissimilarity between levels of affective traits may thus be manifested in a tendency for one system to suppress the other, and similarity between levels of affective traits at more extreme levels may be manifested in those systems being activated together. In contrast, individuals with similar and moderate levels of affective traits typically exhibited asynchrony. This finding makes sense from the purely descriptive observation that most individuals exhibit asynchrony, and that most individuals have moderate levels of affective traits. From a functional perspective, moderate levels of affective traits may promote flexible deployment of approach and avoidance affects in response to the de-

mands of the environment. As neither trait is extremely dominant (or weak), individuals may be able to self-regulate their momentary EA and TA independently of one another. More extreme general affective tendencies might be harder to override through self-regulatory strategies, resulting in one affective system being dominant when levels are dissimilar or affective systems occurring in conflict when levels of affective traits are similar.

Asynchrony may be more adaptive than de-synchrony in stressful situations. Asynchrony (compared to de-synchrony) has been related to feeling less pain in a sample of individuals with osteoarthritis and/or fibromyalgia (Zautra, Johnson, & Davis, 2005) as well as resilience in a sample of recently bereaved individuals (Coifman et al., 2007).

10. Limitations and future directions

There are several limitations to our findings that may be addressed by future research. Because the studies were conducted in naturalistic settings, individual differences may be attributed to environmental rather than personal factors. However, such an explanation would require at least a reason why people chose to be in different environments in the first place. Nonetheless, having participants engage in standardized activities (Borkenau, Mauer, Riemann, Spinath, & Angleitner, 2004) may rule out the possibility that our results are due completely to environmental influences. As our studies were not experimental, we cannot conclude causality or directionality for any of our effects. Future studies may manipulate affects and/or situations to determine whether perceptions and affects have causal influences on each other. Ratings of affects and situation appraisals were all self-reported; thus, it is possible that different results may have been obtained by incorporating observer or peer reports. We urge future researchers to consider adding such reports in order to determine the boundary conditions of our findings. Additionally, women were disproportionately represented in our study and therefore future studies should aim to include a more balanced sample with regard to gender.¹⁰

Although no individual study can explore all potential predictors of synchrony, an individual difference variable not included in this study that may be particularly relevant to synchrony is affective intensity (Larsen, Diener, & Emmons, 1986). Affective intensity reflects the magnitude of a person's emotional responsiveness to emotion-provoking stimuli (e.g., strongly felt negative and positive affective states). Although first considered a unidimensional construct (Larsen, 1985), more recent research (Bryant, Yarnold, & Grimm, 1996) has revealed a three-factor structure of negative reactivity (strong reactions to negative events), negative intensity (feeling negative emotions strongly), and positive intensity (feeling positive emotions strongly). As intuition suggests that intense positive and negative emotions are not felt synchronously (Rafaeli et al., 2007), individuals scoring highly on any of the factors of affect intensity might be less likely to experience affective synchrony; this possibility awaits further research.

Future research may also explore the implications of synchrony for psychological functioning, particularly focusing on determining the conditions under which synchrony may be adaptive or maladaptive. Results from the current studies show that those who experience affect synchronously typically notice the potentially rewarding aspects of negative situations in concert, suggesting that synchrony may provide a buffer against the debilitating aspects of difficult situations. In contrast, it has been proposed that experiencing both positive and negative emotions may consume a relatively large degree of energy (Watson, 2000), raising the

¹⁰ MLMs examining gender as a predictor of synchrony found that gender did not moderate EA–TA associations or Pleasant–Unpleasant associations.

possibility that synchrony may be associated with fatigue and therefore suboptimal cognitive performance (Matthews, Davies, Westerman, & Stammers, 2000).

Finally, because we were concerned with individual differences in relationships between positivity and negativity, we did not attempt to answer the separate question of whether experiences of positive and negative affect were truly simultaneous or whether they occurred sequentially. To do so likely requires integrating methods specialized for separating simultaneous and sequential subjective experiences (Carrera & Oceja, 2007) with neuroimaging techniques that have the ability to analyze brain regions involved in affect and conscious experience with high temporal resolution (Craig, 2010).

11. Conclusion

Researchers are divided over the question of whether positive affect and negative affects should be conceptualized as bipolar opposites (e.g., Russell, 1980; Barrett & Russell, 1998) or independent dimensions (Thayer, 1989; Larsen et al., 2001; Rafaeli & Revelle, 2006). Our findings, however, have consistently suggested that the relationships between positive and negative affects differ between individuals. Thus, the structure of affective space may be conceptualized more accurately as an individual difference variable, and a reliance only on nomothetic studies of affect alone may hinder our understanding of the experience. Findings from this study specifically show that individual differences in Pleasant-Unpleasant space range from de-synchrony to asynchrony, and individual differences in EA–TA space range between de-synchrony and synchrony. Further investigations in the aim of developing an idiographic predictive model of a particular individual's relationship between EA and TA may benefit from focusing on dynamic situation appraisals. Furthermore, taking an approach-avoidance perspective may be particularly fruitful in such investigations. By doing so, we may go beyond an understanding of those situations that are especially likely to provoke mixed emotions to find why people differ in their emotional experience and the circumstances under which particular within-person affective structures are beneficial. In closing, we advocate the use of cell-phone text-messaging as a medium that is well-tailored to investigate individual differences in the structure of affect across time.

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References

- Allport, G. W. (1937). *Personality; a psychological interpretation*. New York: Holt and Company.
- Anhoj, J., & Moldrup, C. (2004). Feasibility of collecting diary data from asthma patients through mobile phones and sms (short message service): Response rate analysis and focus group evaluation from a pilot study. *Journal of Medical Internet Research*, 6(4).
- Barrett, L., & Russell, J. A. (1998). Independence and bipolarity in the structure of current affect. *Journal of Personality and Social Psychology*, 74(4), 967–984.
- Bliese, P. (2009). Multilevel: Multilevel functions. R package version 2.3.
- Bolger, N., Davis, A., & Rafaeli, E. (2003). Diary methods: Capturing life as it is lived. *Annual Review of Psychology*, 54, 579–616.
- Borkenau, P., Mauer, N., Riemann, R., Spinath, F. M., & Angleitner, A. (2004). Thin slices of behavior as cues of personality and intelligence. *Journal of Personality and Social Psychology*, 86(4), 599–614.
- Bryant, F. B., Yarnold, P. R., & Grimm, L. G. (1996). Toward a measurement model of the affect intensity measure: A three-factor structure. *Journal of Research in Personality*, 30, 223–247.
- Bryk, A. S., & Raudenbush, S. W. (1992). Hierarchical linear models: Applications and data analysis methods. *Advanced Qualitative Techniques in the Social Sciences* (Vol. 1). Thousand Oaks, CA: Sage Publications, Inc.
- Carrera, P., & Oceja, L. (2007). Drawing mixed emotions: Sequential or simultaneous experiences? *Cognition & Emotion*, 21(2), 422–441.
- Carver, C. S. (2001). Affect and the functional bases of behavior: On the dimensional structure of affective experience. *Personality and Social Psychology Review*, 5(4), 345–356.
- Carver, C. S., & Harmon-Jones, E. (2009). Anger is an approach-related affect: Evidence and implications. *Psychological Bulletin*, 135(2), 183–204.
- Carver, C. S., & Scheier, M. F. (2000). *Origins and functions of positive and negative affect: A control-process view*. New York, NY: Psychology Press.
- Carver, C. S., & White, T. L. (1994). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS scales. *Journal of Personality and Social Psychology*, 67, 319–333.
- Coifman, K. G., Bonanno, G. A., & Rafaeli, E. (2007). Affect dynamics, bereavement and resilience to loss. *Journal of Happiness Studies*, 8(3), 371–392.
- Collins, R. L., Kashdan, T. B., & Gollnisch, G. (2003). The feasibility of using cellular phones to collect ecological momentary assessment data: Application to alcohol consumption. *Experimental and Clinical Psychopharmacology*, 11(1), 73–78.
- Conner, T. S., Barrett, L. F., Tugade, M. M., & Tennen, H. (2007). Idiographic personality: The theory and practice of experience sampling. In R. W. Robins, R. C. Fraley, & R. F. Krueger (Eds.), *Handbook of research methods in personality psychology* (pp. 79–96). New York, NY: Guilford Press.
- Craig, A. D. (2010). The sentient self. *Brain Structure & Function*, 214(5–6), 563–577.
- Davidson, R. J. (1992). Emotion and affective style: Hemispheric substrates. *Psychological Science*, 3(1), 39–43.
- Depue, R. A., & Collins, P. F. (1999). Neurobiology of the structure of personality: Dopamine, facilitation of incentive motivation, and extraversion. *Behavioral and Brain Sciences*, 22(3), 491–569.
- Emmons, R. A. (1989). Exploring the relations between motives and traits: The case of narcissism. In D. M. Buss & N. Cantor (Eds.), *Personality psychology: Recent trends and emerging directions* (pp. 32–44). New York: Springer-Verlag.
- Ersner-Hersfield, H., Mikels, J. A., Sullivan, S. J., & Carstensen, L. L. (2008). Poignancy: Mixed emotional experience in the face of meaningful endings. *Journal of Personality and Social Psychology*, 94(1), 158–167.
- Feldman, L. A. (1995). Valence focus and arousal focus: Individual differences in the structure of affective experience. *Journal of Personality and Social Psychology*, 69(1), 153–166.
- Fowles, D. C. (1987). Application of a behavioral theory of motivation to the concepts of anxiety and impulsivity. *Journal of Research in Personality*, 21(4), 417–435.
- Gray, J. A. (1994). Personality dimensions and emotion systems. In P. Ekman & R. J. Davidson (Eds.), *The nature of emotion: Fundamental questions* (pp. 243–247). New York: Oxford University Press.
- Gray, J. A., van Goozen, S. H. M., Van de Poll, N. E., & Sergeant, J. A. (1994). Framework for a taxonomy of psychiatric disorder. In *Emotions: Essays on emotion theory* (pp. 29–59). Hillsdale, NJ, England: Lawrence Erlbaum Associates, Inc..
- Hemenover, S. H., & Schimmack, U. (2007). That's disgusting!... but very amusing: Mixed feelings of amusement and disgust. *Cognition & Emotion*, 21(5), 1102–1113.
- Hilgard, E. R. (1980). The trilogy of mind: Cognition, affection, and conation. *Journal of the History of the Behavioral Sciences*, 16, 107–117.
- Hui, C. M., Fok, H. K., & Bond, M. H. (2009). Who feels more ambivalence? Linking dialectical thinking to mixed emotions. *Personality and Individual Differences*, 46(4), 493–498.
- Hunter, P. G., Schellenberg, E. G., & Schimmack, U. (2008). Mixed affective responses to music with conflicting cues. *Cognition & Emotion*, 22(2), 327–352.
- Johnson, J. A. (1997). Units of analysis for the description and explanation of personality. In R. Hogan, J. A. Johnson, & S. R. Briggs (Eds.), *Handbook of personality psychology* (pp. 73–93). San Diego, CA: Academic Press.
- Kauer, S. D., Reid, S. C., Sanci, L., & Patton, G. C. (2009). Investigating the utility of mobile phones for collecting data about adolescent alcohol use and related mood, stress, and coping behaviours: Lessons and recommendations. *Drug and Alcohol Review*, 28, 25–30.
- Klasnja, P., Harrison, B. L., LeGrand, L., LaMarca, A., Froehlich, J., & Hudson, S. E. (2008). Using wearable sensors and real time inference to understand human recall of routine activities.
- Kuntsche, E., & Robert, B. (2009). Short message service (sms) technology in alcohol research feasibility study. *Alcohol and Alcoholism*, 44(4), 423–428.
- Larsen, R. J. (1985). Theory and measurement of affect intensity as an individual difference characteristic. *Dissertation Abstracts International*, 45, 2297.
- Larsen, R. J., & Diener, E. (1992). Promises and problems with the circumplex model of emotion. In M. S. Clark (Ed.), *Emotion* (pp. 25–59). Thousand Oaks, CA: Sage Publications, Inc..
- Larsen, R. J., Diener, E., & Emmons, R. A. (1986). Affect intensity and reactions to daily life events. *Journal of Personality and Social Psychology*, 51(4), 803–814.
- Larsen, J. T., McGraw, A., & Cacioppo, J. T. (2001). Can people feel happy and sad at the same time? *Journal of Personality and Social Psychology*, 81(4), 684–696.
- Larsen, J. T., McGraw, A. P., Mellers, B. A., & Cacioppo, J. T. (2004). The agony of victory and thrill of defeat: Mixed emotional reactions to disappointing wins and relieving losses. *Psychological Science*, 15(5), 325–330.
- Matthews, G., Davies, D. R., Westerman, S. J., & Stammers, R. B. (2000). *Human Performance: Cognition, stress, and individual differences*. Philadelphia, PA: Taylor & Francis.
- Matthews, G., & Westerman, S. J. (1994). Energy and tension as predictors of controlled visual and memory search. *Personality and Individual Differences*, 17(5), 617–626.

- Modi, A. C., & Quittner, A. L. (2006). Utilizing computerized phone diary procedures to assess health behaviors in family and social contexts. *Children's Health Care*, 35(1), 29–45.
- Ong, A. D., & Bergeman, C. S. (2004). The complexity of emotions in later life. *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*, 59(3), 117–122.
- Ortony, A., Norman, D. A., & Revelle, W. (2005). Effective functioning: A three level model of affect, motivation, cognition, and behavior. In J. Fellous & M. Arbib (Eds.), *Who needs emotions? The brain meets the machine* (pp. 173–202). New York: Oxford University Press.
- Pinheiro, J., Bates, D., DebRoy, S., & Sarkar, D. (2009). NLME: Linear and nonlinear mixed effects models. R package version 3.1-96.
- Pytlík Zillig, L. M., Hemenover, S. H., & Dienstbier, R. A. (2002). What do we assess when we assess a big 5 trait? A content analysis of the affective, behavioral and cognitive processes represented in the big 5 personality inventories. *Personality and Social Psychology Bulletin*, 28(6), 847–858.
- Rafaeli, E., & Revelle, W. (2006). A premature consensus: Are happiness and sadness truly opposite affects? *Motivation and Emotion*, 30(1), 1–12.
- Rafaeli, E., Rogers, G. M., & Revelle, W. (2007). Affective synchrony: Individual differences in mixed emotions. *Personality and Social Psychology Bulletin*, 33(7), 915–932.
- R Development Core Team (2009). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0.
- Reich, J. W., Zautra, A. J., & Davis, M. (2003). Dimensions of affect relationships: Models and their integrative implications. *Review of General Psychology*, 7(1), 66–83.
- Reid, S. C., Kauer, S. D., Dudgeon, P., Sanci, L. A., Shrier, L. A., & Patton, G. C. (2008). A mobile phone program to track young people's experiences of mood, stress and coping: Development and testing of the mobiletype program. *Social Psychiatry and Psychiatric Epidemiology*, 44, 501–507.
- Revelle, W. (2011). Psych: Procedures for personality and psychological research. R package version 1.0-92.
- Revelle, W., & Anderson, K. J. (1996). Time of day and activation states: Interactions with impulsivity and neuroticism. Paper presented at the European Association of Personality Psychology, Belgium.
- Russell, J. A. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology*, 39(6), 1161–1178.
- Russell, J. A., & Carroll, J. M. (1999). On the bipolarity of positive and negative affect. *Psychological Bulletin*, 125(1), 3–30.
- Russell, J. A., Lewicka, M., & Niit, T. (1989). A cross-cultural study of a circumplex model of affect. *Journal of Personality and Social Psychology*, 57(5), 848–856.
- Saklofske, D. H., Blomme, G. C., & Kelly, I. W. (1992). The effects of exercise and relaxation on energetic and tense arousal. *Personality and Individual Differences*, 13(5), 623–625.
- Schimmack, U., & Grob, A. (2000). Dimensional models of core affect: A quantitative comparison by means of structural equation modeling. *European Journal of Personality*, 14(4), 325–345.
- Schimmack, U., & Reisenzein, R. (2002). Experiencing activation: Energetic arousal and tense arousal are not mixtures of valence and activation. *Emotion*, 2(4), 412–417.
- Shrout, P. E., & Fleiss, J. L. (1979). Intraclass correlations: Uses in assessing rater reliability. *Psychological Bulletin*, 86(2), 420–428.
- Smillie, L. D., Loxton, N. J., & Avery, R. E. (in press). Reinforcement sensitivity theory, research, applications, and future. In Chamorro-Premuzic, T., Furnham, A. F., & von Stumm, S. (Eds.), *Handbook of individual differences*. Wiley-Blackwell, London, UK.
- Solomon, R. L. (1980). The opponent-process theory of acquired motivation: The costs of pleasure and the benefits of pain. *American Psychologist*, 35(8), 691–712.
- Thayer, R. E. (1989). *The biopsychology of mood and arousal*. New York, NY: Oxford University Press. xi, 234 pp..
- Watson, D. (2000). *Mood and temperament. Emotions and social behavior*. New York: Guilford Press.
- Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, 54(6), 1063–1070.
- Watson, D., Wiese, D., Vaidya, J., & Tellegen, A. (1999). The two general activation systems of affect: Structural findings, evolutionary considerations, and psychobiological evidence. *Journal of Personality and Social Psychology*, 76(5), 820–838.
- Wildschut, T., Sedikides, C., Arndt, J., & Routledge, C. (2006). Nostalgia: Content, triggers, functions. *Journal of Personality and Social Psychology*, 91(5), 975–993.
- Wilt, J., & Revelle, W. (2009). Extraversion. In M. Leary & R. Hoyle (Eds.), *Handbook of individual differences in social behavior* (pp. 27–45). New York: Guilford.
- Winter, D. G., John, O. P., Stewart, A. J., Klohnen, E. C., & Duncan, L. E. (1998). Traits and motives: Toward an integration of two traditions in personality research. *Psychological Review*, 105(2), 230–250.
- Yik, M. S. M., Russell, J. A., & Barrett, L. F. (1999). Structure of self-reported current affect: Integration and beyond. *Journal of Personality and Social Psychology*, 77(3), 600–619.
- Zautra, A. J. (2003). *Emotions, stress, and health*. New York: Oxford University Press.
- Zautra, A. J., Berkhof, J., & Nicolson, N. A. (2002). Changes in affect interrelations as a function of stressful events. *Cognition & Emotion*, 16(2), 309–318.
- Zautra, A. J., Johnson, L. M., & Davis, M. C. (2005). Positive affect as a source of resilience for women in chronic pain. *Journal of Consulting and Clinical Psychology*, 73(2), 212–220.