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Differences in Within- and Between-Person Factor Structure of Positive and Negative Affect: Analysis of Two Intensive Measurement Studies using Multilevel SEM

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Abstract

The Positive and Negative Affect Schedule (PANAS) is a widely used measure of emotional experience. The factor structure of the PANAS has been predominantly examined with cross-sectional designs, which fails to disaggregate within-person variation from between-person differences. There is still uncertainty as to the factor structure of positive and negative affect and whether they constitute two distinct independent factors. The present study examined the within-person and between-person factor structure of the PANAS in two independent samples that reported daily affect over 7 and 14 occasions, respectively. Results from multilevel confirmatory factor analyses revealed that a two factor structure at both the within- and between-person level, with correlated specific factors for overlapping items, provided good model fit. The best-fitting solution was one where within-person factors of positive and negative affect were inversely correlated, but between-person factors were independent. The structure was further validated through multilevel structural equation modeling examining the effects of cognitive interference, daily stress, physical symptoms, and physical activity on positive and negative affect factors.

Keywords

Multilevel confirmatory factor analysis; affect; emotion; PANAS; multilevel structural equation modeling

The study of emotional experience has a long history in psychological research and has often been used to reflect one's level of well-being. The subjective experience of emotional states have been conceptualized as belonging to two broad emotional dimensions, referred to as positive affect (PA) and negative affect (NA; e.g., Diener & Emmons, 1985; Watson & Tellegen, 1985). Positive affect is characterized as an experience of pleasurable engagement with one's environment, whereas NA is characterized as unpleasant engagement (Watson, Clark, & Tellegen, 1988). Affect has been associated with a wide-range of mental and physical health variables, such as depression and anxiety (Beck et al., 2003; Watson, Clark, & Carey, 1988), physical illness and pain (Hu & Gruber, 2008), quality of life, and self-esteem (Caprara et al., 2012; Zeigler-Hill & Abraham, 2006). The measurement and understanding of PA and NA have been researched and used extensively in both clinical

(e.g., Beck et al., 2003; Jolly, Dyck, Kramer, & Wherry, 1994) and normative populations (e.g., Crawford & Henry, 2004). Most of this research has aimed at explaining individual differences in affect. However, a deeper understanding of the individual can be gained by examining the structure, changes, and variations of emotional states within an individual over time. A greater emphasis on the measurement properties that adequately capture variation within an individual, as well as differences between individuals, is needed to guide scientific and clinical assessment of the individual's affective experience.

One of the most widely used measures of PA and NA has been the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988). The PANAS consists of 10 adjectives selected to reflect PA (e.g., interested, excited, proud) and 10 adjectives that reflect NA (e.g., upset, nervous, irritable) that were derived from Zevon and Tellegen's (1982) mood content categories. Watson and colleagues (Watson & Tellegen, 1985; Watson et al., 1988) originally conceptualized PA and NA as comprising of two distinct constructs that were independent of one another and shared unique relationships with relevant predictor variables. The conceptualization of PA and NA as independent had been established by prior research demonstrating a lack of relationship between the two constructs (Bradburn, 1969; Diener & Emmons, 1985; Zevon & Tellegen, 1982). However, it has been argued that PA and NA are opposite ends of the same dimension (e.g., Russell, 1980), where the experience of PA precludes the experience of NA, or vice versa. Much research continues to follow this approach by creating a single 'affect balance' score that subtracts NA from PA (e.g., Liu, Wang, & Lü, 2013). An additional conceptualization that has found support is that the two constructs form distinct dimensions that are inversely correlated with one another (Green, Goldman, & Salovey, 1993; Green & Salovey, 1999). Each of these conceptualizations of PA and NA has implications for how the PANAS is utilized and what conclusions can be drawn from its use.

In the 25 years since its development the factor structure of the PANAS has been examined frequently through both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). Based on these results, general consensus has been established that a two-factor model of PA and NA provides better fit than a single, bipolar factor (Crawford & Henry, 2004; Crocker, 1997; Terracciano, McCrae, & Costa, 2003; Tuccitto, Giacobbi, Jr., & Leite, 2010; Watson et al., 1988). However, the two-factor model frequently failed to produce acceptable fit to the data according to CFA (Crawford & Henry, 2004; Crocker, 1997; Gaudreau, Sanchez, & Blondin, 2006; Leue & Beauducel, 2011; Terracciano et al., 2003; Tuccitto et al., 2010). The poor fit of the two-factor model has led researchers to propose that because the items were generated from Zevon and Tellegen's (1982) mood content categories, a number of the items are overlapping and nearly redundant, resulting in items of the same mood category sharing variance that is not shared among the common factors (i.e., PA and NA). For example, the items guilty and ashamed are more similar to each other than are the items guilty and hostile. To account for this a number of studies have permitted the items' specific factors (i.e., variance unique to the indicator and not shared by the common factors) to correlate with other items belonging to the same mood category (see Table 1). The results of this a priori specification have consistently revealed that allowing items to correlate according to Zevon and Tellegen's mood categories improves model fit and the

resulting two-factor model demonstrates acceptable to good overall model fit (e.g., Crawford & Henry, 2004; Merz & Roesch, 2011; Tuccitto et al., 2010).

Results pertaining to the independence of the two-factor model have been less consistent. It is still unclear from the literature if the PA and NA factors are best represented as two independent factors, or two inversely correlated factors. A number of studies have demonstrated that two correlated factors fit best, where PA and NA factors show a moderate, inverse relationship (e.g., Crawford & Henry, 2004; Green et al., 1993). However, other studies have found that two independent factors produce the best fit (Kercher, 1992; Tuccitto et al., 2010).

The equivocal findings are potentially due to the nature of the studies and their design. Nearly all research examining the factor structure of the PANAS has been based on cross-sectional data measured at a single time point. Conclusions based on this form of data are limited to the between-person level, where inversely correlated PA and NA factors only indicates that individuals who are higher (or lower) than others on PA (according to their rank-ordering) are also lower (or higher) than others on NA. It does not inform about the co-occurrence of PA and NA (i.e., the within-person relationship). Furthermore, given that affect has been shown to fluctuate within an individual over short periods of time (e.g., days; Rast, Hofer, & Sparks, 2012; Röcke, Li, & Smith, 2009), only examining cross-sectional data ignores the within-person variability that is present in the single time-point measure. Thus, the between-person estimates derived from cross-sectional data are confounded by within-person variability (Curran & Bauer, 2011; Hoffman & Stawski, 2009). This becomes particularly problematic if there is a within-person relationship, such as what would be expected if PA and NA were unlikely to occur simultaneously. The influence of the within-person correlation on the between-person relationship may be producing the inconsistencies in the relationship between PA and NA factors frequently observed in cross-sectional research. It may not be that individuals who are higher on PA relative to others are the same individuals who are lower on NA, but rather that the within-person variance has confounded the between-person estimates resulting in an apparent relationship that may be spurious.

In order to gain a more thorough understanding of the independence of PA and NA, the factor structure at the between-person and within-person levels need to be considered. Disaggregation of within-person variance from between-person can only be accomplished with repeated measure designs to allow the within-person fluctuations in affect to be modeled separately from the between-person differences. By applying an intensive repeated measure design, both a within-person and between-person factor structure can be examined simultaneously through the use of multilevel factor analysis. In multilevel factor analysis, the within-person factor structure reflects common covariance in indicators within-person (i.e., on a given occasion), pooled across occasions and individuals. The between-person factor structure reflects common covariance in individual levels of indicators aggregated across time. The between-person factor structure would provide insight to whether individuals experience both PA and NA on average relative to others, whereas the within-person factor structure provides the important test of whether PA and NA co-occur on the same occasion. Thus, PA and NA could be independent when evaluated as an individual difference (i.e., between-person level; Diener & Emmons, 1985; Diener, Smith, & Fujita,

1995; Watson et al., 1988), but correlated or even bipolar, such that they do not co-occur, when evaluated on the within-person level.

The multilevel structure of affect has received sparse attention. In a daily diary study that consisted of five measurement occasions, Merz and Roesch (2011) evaluated the within- and between-person factor structure of the PANAS through multilevel CFA. It was concluded that two correlated factors at both the within-person and between-person level (with correlated specific factors) fit best when compared to a model that specified two independent within-person and between-person factors. However, the authors failed to test a model that specified different factor structures at the within-person and between-person levels, thereby implying a “functional unity” (Cattell, 1950) in the structure of affect (i.e., that the relationships between persons are equivalent to the relationships within a person across occasions). By only specifying models that were identical across both levels, two important models for understanding the nature of independence of PA and NA were neglected: i) a model that specified a single factor at the within-person level, but two independent factors at the between-person level; and ii) a model where PA and NA are permitted to correlate at the within-person level, but are constrained to be independent at the between-person level. Given that these two models were not evaluated and that the between-person factor correlation of Merz and Roesch's final model was non-significant, it does not seem conclusive that two correlated factors best represents the within- and between-person factor structure of the PANAS.

Zimprich and Allemand (2012) also examined the multilevel factor structure of affect in a sample of 79 older adults repeated over 21 days. Though this study used a different emotional adjective list than the PANAS (i.e., satisfied, happy, confident, joyful, hopeful, disappointed, sad, anxious, worried, gloomy), they also found that a two-factor solution at both the within- and between-person level fit best ($SRMR_{WP} = .04$, $SRMR_{BP} = .08$, $RMSEA = .05$). However, constraining the factor correlations to be equal across both levels resulted in poorer model fit, such that the within-person interfactor correlation was significantly stronger than the between-person interfactor correlation ($\chi^2(1) = 19.08$, $p < .05$). Other studies have examined multilevel correlations between observed affect measures. Vansteelandt, Van Mechelen, and Nezlek (2005) measured affect using a list of eight negative emotions and four positive emotions and found that the correlations between specific PA and NA items at the between-person level was .03 on average, but the within-person correlation was $-.29$. Similarly, Diener and Emmons (1985), using a measure comprised of four PA items and five NA items, found that within-person correlations of PA and NA were stronger than between-person correlations. Based on these multilevel studies, where within-person variations have been disaggregated from between-person differences, it appears that the experience of PA and NA are less likely to occur when measured on the same occasion, but the relationship is small to non-existent when measured at the between-person level. However, it is still unclear if the within-person correlation is strong enough to be indicative of a single bipolar factor (i.e., $r = -1.0$) and also if the between-person correlation is weak enough to be indicative of two independent factors (i.e., $r = 0$). Both of these issues can be formally tested with multilevel CFA.

In addition to the nature of the factor structure of the PANAS, it is an important step to validate the multilevel structure of PA and NA at the latent level. Positive and negative affect are frequently used as outcome variables that have been shown to be predicted by a number of relevant variables at both the within-person and between-person level. However, multilevel models have typically treated PA and NA as manifest variables (i.e., total scores) rather than treated as latent variables, disattenuated from measurement error. To demonstrate that established effects remain and also show differential effects in predicting within-person fluctuations and between-person differences, four predictor variables (cognitive interference, daily stressor, physical symptoms, and physical activity) were examined. These variables were included based on their relevance for clinical application (e.g., Clark, 2004; Hammen, 2005; Hu & Gruber, 2008; Ng, Dodd, & Berk, 2007) and their common use in intensive measurement studies accounting for within-person and between-person effects of affect.

Cognitive interference, which is the presence of intrusive, off-task thoughts that interfere with normal task-oriented thinking, has been found to directly relate to NA at both the within- and between-person levels (Stawski, Mogle, & Sliwinski, 2011). Similarly, research has repeatedly demonstrated a direct within-person effect of daily stress on NA (Sliwinski, Almeida, Smyth, & Stawski, 2009; Stawski, Sliwinski, Almeida, & Smyth, 2008). However, research has often failed to find a within-person relationship between daily stress and PA in young adult samples (e.g., Stawski et al., 2008). Furthermore, there has been little empirical support for a between-person effect of daily stress predicting either PA or NA (Sliwinski et al., 2009; Stawski et al., 2008). The experience of physical symptoms, such as illness or physical pain, has been shown to directly relate to NA and inversely relate to PA (Hu & Gruber, 2008; Flett, Molnar, Nepon, & Hewitt, 2012; Reis, Sheldon, Gable, Roscoe, & Ryan, 2000). Finally, engaging in physical activity has been shown to directly relate to PA, but not NA, at both the within-person (Wichers et al., 2012) and between-person (Pasco et al., 2011) level.

Present Study

The within-person and between-person structure of the PANAS was examined with two independent samples that employed an intensive repeated measurement design, where many measurement occasions are assessed over a relatively short interval of time (i.e., daily diary). Through the use of multilevel CFA, a series of hypotheses were tested by evaluating a number of competing models. The main research objectives regarding the multilevel structure of the PANAS were to determine if the within-person correlation is strong enough to be indicative of a single bipolar factor (i.e., $r = -1.0$), rather than two distinct, but correlated factors; and also if the between-person correlation is weak enough to be indicative of two independent factors (i.e., $r = 0$). Examining two independent samples allowed for the measurement and structural results to be cross-validated, which serves as a key demonstration of the stability of the models.

Based on empirical and theoretical grounds it was expected that two distinct factors at both the within-person and between-person level would represent the best fitting solution of the PANAS (Merz & Roesch, 2011; Zimprich & Allemand, 2012). However, contrary to Merz and Roesch, it was believed that the within-person PA and NA factors would be inversely

correlated, but the between-person PA and NA factors will be independent, as originally conceptualized by Watson and colleagues (Watson & Tellegen, 1985; Watson et al., 1988). Finally, permitting the item's specific factors to correlate according to Zevon & Tellegen's (1982) mood content categories was expected to improve model fit.

The within-person and between-person factor structure of PA and NA was then validated through a series of multilevel structural equation models (SEM) that examined the ability of cognitive interference, daily stressors, physical symptoms, and physical activity to differentially predict latent PA and NA at both a within-person and between-person level. The presence of cognitive interference, daily stressors, and physical symptoms was expected to be more strongly related to NA than PA. Conversely, engaging in physical activity was expected to predict PA more strongly than NA.

Method

Participants and Procedure

Sample 1—Participants were recruited through a university-based participant pool targeting undergraduates in Psychology. Additional recruitment included announcements in psychology courses and posted flyers on campus. Participants were compensated for their time with extra course credit offered through the psychology department as well as a monetary amount of \$25. Data were collected over two spring terms (2010 and 2011) amounting to $N = 179$ participants (79% female; 71% Caucasian, 15% Asian, 2% Indian, 12% Other; 52% Social Sciences majors; $M_{age} = 20.6$, $SD = 4.37$).

Participants were tested seven times over the course of 10 – 14 days, with a minimum time of 24 hours between sessions. Each testing session took place in a lab setting, where participants completed three computerized cognitive tasks that are not relevant to the current study. This was followed by a computer-based questionnaire to assess daily PA and NA, cognitive interference, daily stressors, and physical symptoms, in addition to basic demographic information. Of a possible 1253 testing occasions (179 participants X 7 occasions), data from 1233 occasions were obtained (98%; $M_{occasions} = 6.9$; see Rast et al., 2012).

Sample 2—One hundred forty-seven undergraduate students (87% female; 73% Caucasian, 12% Asian, 3% Indian, 12% Other; 60% Social Sciences majors; $M_{age} = 19.9$, $SD = 3.2$) from the same university formed the sample collected in 2012. They were recruited through the same research participant pool in exchange for extra credit in a psychology course.

Participants were invited to an instruction session where they completed a preliminary web-based questionnaire consisting of demographic information and were informed of the protocol for completing the daily diary portion of the study. Beginning on the following day, participants completed a daily web-based questionnaire each evening for 14 consecutive days between the hours of 6:00 pm and 2:00 am. Daily questionnaires that were not completed during that period were considered missing. Each questionnaire consisted of daily measures of the PANAS, cognitive interference, stressors, and physical activity. Of a

possible 2058 daily questionnaires (147 participants X 14 days), data for 1644 complete days were obtained (80%; $M_{occasions} = 11.2$).

Measures

Positive and negative affect—Positive and negative affect were assessed using the PANAS (Watson et al., 1988). Participants were presented with a list of 20 emotions (see Table 1) and asked to “read each item and then indicate to what extent you have felt this way in the past 24 hours”. Responses ranged from 1 (*very slightly or not at all*) to 5 (*extremely*). To eliminate order effects, the order of the items was randomly presented each occasion.

Cognitive interference—Cognitive interference (CI) was measured using the short cognitive interference measure (Stawski et al., 2011). This six-item measure assessed the frequency of experiencing intrusive thoughts (e.g., “In the last 24 hours, how often did you think about something you didn't mean to?”) and attempts to avoid thinking about stressful thoughts (e.g., “In the last 24 hours, how often did you try to avoid certain thoughts?”). Sample 1 participants responded to the six items on a 1 (*never*) to 5 (*very often*) scale, whereas sample 2 participants responded on a 1 (*never*) to 10 (*constantly*) scale. A daily cognitive interference score was computed by averaging across the six items. The sample 2 CI score was rescaled (i.e., divided by 2) to range from 1 to 5 in order to aid in the comparison of regression coefficients across both samples.

Daily stressors—Daily stressors were assessed using the Daily Inventory of Stressful Events (Almeida, 1998). The inventory consisted of six questions inquiring whether certain types of stressors had been experienced in the last 24 hours (e.g., “In the past 24 hours, did you have an argument or disagreement with anyone?”). A dichotomous variable was used to characterize days as either stress days (at least one stressor was reported) or nonstress days (no stressor reported).

Physical symptoms (sample 1 only)—Five questions (e.g., “In the past 24 hours, how frequently did you experience discomfort/tightness in your chest, rapid heart rate, or dizziness?”) assessed the frequency participants experienced physical symptoms (e.g., aches/pains, gastrointestinal symptoms, discomfort/tightness in the chest, flu-like symptoms). Responses to these questions were made on a 5-point scale ranging from 1 (*none of the time*) to 5 (*all of the time*). A daily physical symptom score was computed by summing the values of the 5 items.

Physical activity (sample 2 only)—A single, dichotomous item was used to indicate whether or not participants had engaged in physical activity each day (e.g., “In the last 24 hours, have you engaged in physical activity (e.g., running, walking, yoga, sports)?”).

Data Analytic Strategy

Multilevel confirmatory factor analyses were employed to evaluate the optimal within-person and between-person factor structure of the PANAS. Multilevel CFA allows for the within-person (WP) variance to be disaggregated from the between-person (BP) variance,

while still attenuating for measurement error at both levels. The multilevel measurement model can be expressed by the following equation (Muthén, 1991; Preacher, Zyphur, & Zhang, 2010):

$$Y_{ij} = \nu + \lambda_w \eta_{ij} + \varepsilon_{ij} + \lambda_b \eta_i + \varepsilon_i,$$

where Y_{ij} is a p -dimensional vector of observed variables for individual i on occasion j , where p is the number of observed indicators; ν is a p -dimensional vector of intercepts; λ_w is a $p \times q$ within-person factor loadings matrix, where q is the number of latent variables; λ_b is a $p \times q$ between-person factor loadings matrix; η_{ij} and η_i are q -dimensional vectors of within-person and between-person latent variables, respectively; and ε_{ij} and ε_i are p -dimensional vectors of within-person and between-person specific factors (i.e., variance unique to the indicators), respectively.

At the BP level, the indicators are person means of each WP indicator that are aggregated in order to adjust for unreliability in sampling error (see Lüdtke et al., 2008; Marsh et al., 2009 for further details), such that the BP indicators are represented as latent means. Both the BP and WP parts of the model are estimated simultaneously with the WP factor structure representing common covariance in the indicators at each specific occasion across time and BP factor structure representing common covariance in the person-mean indicators across people. The chi-squared statistic (χ^2), comparative fit index (CFI), root mean square error of approximation (RMSEA) and standardized root mean square residual (SRMR) were applied to evaluate the fit of the model to the observed data. The CFI and RMSEA provide indices of overall model fit (i.e., across both levels), whereas the SRMR provides level-specific fit indices. According to Hu and Bentler (1999), CFI values greater than .90 indicate an acceptable fitting model and greater than .95 represent good model fit. RMSEA below .08 indicate plausible fit and below .05 is indicative of good fit. SRMR values below .08 indicate acceptable fit, and below .05 represent good fit.

Given that the PANAS items were measured on five ordered categories, the decision to treat them as continuous or ordinal is not straightforward. Recent simulation studies have demonstrated that treating variables with five or more categories as continuous perform as well in estimating CFA models as when treated as ordinal (Rhemtulla, Brosseau-Liard, & Savalei, 2012). Furthermore, analyzing the models as both continuous and ordinal yielded a similar pattern of results across both approaches and did not impact the conclusions to be drawn. The majority of previous research on the structure of the PANAS has treated the items as continuous. Therefore, only the results of the continuous treatment of the PANAS are presented to better enable the results of the current study to be compared and interpreted within the context of past research. All models were estimated using Mplus v6 (Muthén & Muthén, 2010) with maximum likelihood for robust estimates (MLR). Nested models were compared using a scaled χ^2 difference test¹.

¹Chi-square values obtained from MLR estimation procedures are not distributed on a χ^2 distribution and were rescaled using the procedure outlined on the Mplus website (www.statmodel.com/chidiff) in order to allow for comparison between nested models.

Parameterization of PANAS multilevel CFA models—Model 1A tested a model comprised of a single factor at both the WP and BP level in order to test the hypothesis that affect is best conceptualized as a unidimensional factor where positive and negative items load onto the same factor in a bipolar nature (Figure 1a). Model 2A tested the hypothesis that affect is best represented by a unidimensional/bipolar factor at the WP level (i.e., the expression of PA and NA does not co-occur at the same occasion) but a two factor solution at the BP level (i.e., that PA and NA are independent on average; Figure 1b).

Model 3A evaluated a model of two independent factors (PA and NA) at both the WP and BP level (Figure 2a). Model 3A was nested within 4A, which differed by allowing the two factors to correlate at both the WP and BP level (Figure 2b). Finally, Model 5A allowed the two WP factors (PA and NA) to correlate, but constrained the two BP factors (PA and NA) to be independent (Figure 2c). Comparing Model 5A to Models 3A and 4A provided a formal test of the independence of the PA and NA factors at both the WP and BP level.

Each ‘A’ model was tested against its corresponding ‘B’ model that allowed the item's specific factors to correlate at both the WP and BP levels according to Zevon and Tellegen's (1982) mood content categories (Figure 3 displays the items that were permitted to correlate).

Validation of the PA and NA factors—The measurement model displayed in Figure 3 (Model 4B)² was extended to include an exogenous WP and BP covariate/predictor. The latent PA and NA variables were treated as endogenous, which allowed the WP and BP effects of the predictor to be estimated for PA and NA simultaneously. Daily cognitive interference, stressors, physical symptoms, and physical activity were each entered as a WP and BP predictor in four separate multilevel SEMs. Each model included only one predictor that was person-mean centered at the WP level and person-mean levels were entered at the BP level to generate WP and BP effects. Age and sex were also included as exogenous covariates at the BP level to adjust for individual differences in age-heterogeneity and gender effects.

Results

Means, standard deviations, and intraclass correlations coefficients (ICC) of the PANAS items for samples 1 and 2 are presented in Table 1. Sample 1 ICCs ranged from .25 (*upset*) to .51 (*guilty*) with a mean ICC of .43. Sample 2 had slightly lower ICC values with a mean of .33 and a range from .24 (*nervous*) to .42 (*ashamed*). In both samples, more variability was observed within-person on the PANAS items than between-person. Multilevel reliability estimates (ω) were computed for the PA and NA scales (Geldhof, Preacher, & Zyphur, in press). Within-person $\omega_{\text{samp1/samp2}} = 0.83/0.84$ and $0.80/0.82$ for the PA and NA scales, respectively. Between-person $\omega_{\text{samp1/samp2}} = 0.94/0.96$ and $0.93/0.97$ for the PA and NA scales, respectively.

²Model 4B was chosen to allow the correlation between PA and NA at the between-person level to be freely estimated. These models were also run with Model 5B and the results were essentially identical.

Multilevel Confirmatory Factor Analyses

Model fit indices for all ten of the multilevel CFAs for samples 1 and 2 are presented in Table 2. Chi-squared difference tests that compared each ‘B’ model to its respective ‘A’ model (e.g., Model 1A vs. 1B; Model 2A vs. 2B, etc.) revealed that allowing the specific factors to correlate according to Zevon and Tellegen's mood categories significantly improved model fit in all cases (see Table 2).

The one factor solution at both the WP and BP level (Model 1B) did not provide good fit on any of the fit indices. Similarly, specifying a single WP factor and two independent BP factors (Model 2B) did not produce adequate model fit³. Moving to a two-factor solution at both the WP and BP levels, where the PA and NA factors were constrained to be independent at both levels provided acceptable fit to the data of both samples, but only when the specific factors were permitted to correlate (Model 3B).

Allowing the PA and NA factors to correlate at both the WP and BP levels once again yielded good model fit when specific factors were allowed to correlate (Model 4B) and provided slight improvements in fit indices over Model 3B. A formal χ^2 difference test revealed that allowing for correlated PA and NA factors at both the WP and BP levels improved model fit over the model that constrained the WP and BP factors to be independent (scaled $\chi^2(2) = 58.41$ and 15.64 , $ps < .001$, for samples 1 and 2, respectively). Figure 3 displays the standardized factor loadings and correlations for Model 4B, where the PA and NA factors are inversely related at the WP level ($r = -.38$ and $-.23$, $ps < .001$, for samples 1 and 2, respectively), but are not correlated at the BP level ($r = -.08$ and $-.001$, $ps > .46$, for samples 1 and 2, respectively).

The final model that constrained the PA and NA factors to be independent at the BP level, but allowed them to correlate at the WP level (Model 5B), revealed no degradation in the model fit indices compared to Model 4B in either sample. A χ^2 difference test comparing Model 4B to Model 5B resulted in no degradation in model fit for Model 5B in either sample (scaled $\chi^2(1) = 0.88$ and 0.79 , $ps > .05$ for samples 1 and 2, respectively). Thus, constraining the BP factor correlations between PA and NA to be zero did not result in a reduction in model fit. Taken together, the acceptable fit indices of Model 5B in combination with the χ^2 difference test results indicate that the optimal structure is one in which there are two inversely correlated PA and NA factors at the WP level and two independent PA and NA factors at the BP level.

Validation through Multilevel SEM

A series of multilevel SEMs were conducted to evaluate the relationship of the PA and NA latent variables to well-known predictors of PA and NA at both the WP and BP levels of analysis (i.e., cognitive interference, daily stressors, physical symptoms, and physical activity). Descriptive statistics and intercorrelations among the aggregated daily predictor variables are presented in Table 3.

³Also tested a one within-person factor and two correlated between-person factor, which produced similar poor fit. Only the model with one within-person factor and two independent between-person factors was reported for reasons of parsimony and because this provides a test of the hypothesis that affect is bipolar at the within-person level but independent at the between-person level.

Table 4 presents the results of the multilevel SEM models. Each of the predictors demonstrated effectiveness in predicting PA and NA factors at the within-person level and all significant results were in the expected direction. Occasions when participants reported greater than typical levels of CI, stressors, or physical symptoms, latent PA was lower and NA was higher. Conversely, on occasions when participants reported engaging in physical activity, their PA was higher and their NA was lower.

The predictive ability of the exogenous variables differed at the BP level. Cognitive interference, physical symptoms, and physical activity were also significant between-person predictors of PA and NA, with all associations being in the expected direction (see Table 4). That is, individuals who reported greater CI, physical symptoms, and physical activity on average relative to others, also experienced greater NA and lower PA on average (direction was reversed for physical activity). However, mean number of stress days (BP predictor of daily stressor) was not a significant predictor of average levels of PA in either sample or NA in sample 2 (it was significant in sample 1, $estimate = .62, p < .05$).

The effect sizes (R^2) of all variables differed at the WP and BP level for both PA and NA. Furthermore, CI, daily stressors, and physical symptoms explained more variance in NA than PA, whereas physical activity explained more variance in PA than NA. This was true for both within-person and between-person effects and was consistent across samples.

Discussion

The nature of the factor structure of affect has been predominantly examined with cross-sectional data that fails to disaggregate within-person variability from between-person estimates, rendering the between-person factor structure confounded and the within-person factor structure neglected. To fully understand the structure and dimensionality of affect both within-person and between-person elements need to be incorporated into our models. The present study utilized an intensive repeated measures design in order to model the within-person and between-person structure of affect in two independent samples. Multilevel CFA enabled for important issues pertaining to the independence of PA and NA to be formally tested and multilevel SEM was employed to examine the differential effects key predictors had on PA and NA factors at within- and between-person levels.

Results from the multilevel CFA were consistent across the two independent samples, providing support for the stability of the models. Consistent with previous research, a single-factor model of within-person and between-person affect was rejected as an acceptable model (Merz & Roesch, 2011; Zimprich & Allemand, 2012). The model testing a single within-person affect factor, but two between-person factors was also rejected as a plausible model. Failure of the single-factor models to provide acceptable model fit indicates that a single bipolar conceptualization of affect is not supported and that the occurrence of one valence of affect does not preclude the occurrence of the other. Thus, it appears that the correlation of PA and NA factors at the within-person level does not approach -1.0 .

The two-factor models demonstrated improved fit over the single-factor model. The issue of the independence of these two PA and NA factors at both levels was formally tested. Similar

to Merz and Roesch (2011), we found that two correlated within-person and between-person factors provided improved fit over two independent within-person and between-person factors. However, extending what Merz and Roesch found, allowing the within-person factors of PA and NA to correlate, but constraining the between-person factors of PA and NA to be independent (i.e., $r = 0$) did not reduce the model fit when compared to a model where PA and NA factors were permitted to correlate at both levels. Individuals' general experience of PA (averaged over time) does not offer any indication of the extent that they experience NA, and vice versa. One may experience both PA and NA over time, but at differing times. The inverse relationship observed at the within-person level indicates that individuals are not likely to experience both PA and NA at the same occasion. However, given that the within-person interfactor correlation was only moderately large, the experience of one valence of affect does not preclude the experience of the other. They are inverse, but still distinct.

Taken together, it becomes clear that when within-person variance is disaggregated from between-person estimates, the original conception of two independent between-person dimensions of PA and NA is supported (Bradburn, 1969; Diener & Emmons, 1985; Diener et al., 1995; Watson & Tellegen, 1985; Watson et al., 1988). The notion that an individual is not likely to experience both PA and NA at the same time is also supported, however not to the extent that they would be regarded as polar opposites. These findings provide clear conclusions on the use of measures of PA and NA. Frequently, between-person measures of PA and NA are combined to create an 'affect balance' score (e.g., Koydemir, Simsek, Schütz, & Tipandjan, 2013; Liu et al., 2013). Given the independence of PA and NA at the between-person level, this approach should be avoided and the measures of PA and NA should be kept distinct.

In addition to the number and correlation of within-person and between-person factors, the issue of permitting the item's specific factors to correlate according to Zevon and Tellegen's (1982) mood categories was consistent with what has been observed in the past (Crawford & Henry, 2004; Merz & Roesch, 2011; Tuccitto et al., 2010). Model fit statistics were not in the acceptable range unless the specific factors for overlapping items were permitted to correlate, which improved model fit in all cases. This indicates that there is some shared variance between these items that are not being accounted for by the common factors of PA and NA. That is, items belonging to the same mood categories are related to one another in ways that they are not related to the common PA and NA factors. Failing to specify these additional correlations among items from the same mood category results in poorer overall model fit. The unique correlations between these items are likely due to their redundancy (e.g., afraid and scared).

The factor structure of PA and NA was further validated by demonstrating the differential relationships between relevant covariates and PA and NA factors at both levels of analysis. Cognitive interference significantly predicted within-person and between-person PA and NA factors. The within-person relationship indicates that on occasions when individuals experienced greater CI than is typical for them, they also experienced greater NA and less PA. The between-person relationship indicates that individuals who experience more CI on average relative to others also experience more NA and less PA on average. This is

consistent with multilevel analysis that examined these relationships based on manifest variables (Stawski et al., 2011). Daily stressors also demonstrated predictive ability to account for within-person fluctuations in PA and NA factors, but not for between-person differences (with the exception of between-person NA in sample 1). Experiencing a stressor has been repeatedly shown to co-occur with greater levels of NA (e.g., Sliwinski et al., 2009; Stawski et al., 2008). However, individuals who have a greater number of stress days does not typically predict average levels of PA or NA in young adult samples (i.e., between-person relationship is often non-significant; Stawski et al., 2008). The findings of the present study corroborate this effect and highlight the importance of accounting for both within-person and between-person effects.

Physical symptoms and physical activity both predicted within-person and between-person effects of PA and NA factors. The direction of the relationships between physical symptoms and affect are consistent with previous research (e.g., Flett et al., 2012; Reis et al., 2000). On occasions when individuals were experiencing greater physical symptoms than was typical, their experience of PA was lower and their experience of NA was greater. Individuals who experienced greater physical symptoms on average relative to others also experienced less PA and more NA on average. Conversely, on occasions when individuals reported engaging in physical activity, their PA was higher and their NA was lower. Similarly, those who engaged in physical activity more regularly than others also experienced higher PA and lower NA on average. The direct relationship between physical activity and PA is consistent with research that has examined within-person effects (e.g., Wichers et al., 2012) and between-person effects (Pasco et al., 2011) of physical activity and PA. Contrary to previous research, a significant inverse relationship between physical activity and NA was observed at both the within- and between-person levels. The use of latent variables, that disattenuates measurement error, could explain why the results of the current study detected relationships that had not been found in previous research with manifest variables (e.g., daily stress and PA; physical activity and NA).

The within-person and between-person relationships were typically in the same direction, although, the magnitude of effect sizes differed across levels. Furthermore, both PA and NA were reliably predicted by the same variables, albeit in the opposite direction. However, inspection of the effect sizes clearly reveals that the presence of distressing variables (i.e., cognitive interference, daily stressors, and physical symptoms) explained a greater proportion of variance in NA than PA at both levels of analysis. Conversely, engaging in physical activity, which is often associated with positive experiences (Pasco et al., 2011; Wichers et al., 2012), explained more variance in PA than NA at both levels of analysis. Therefore, the within- and between-person factors of PA and NA appear to be capturing the constructs they are intended to as evident by the discriminant and convergent validity of the predictor variables.

Limitations and Future Directions

A limitation of the present study was the use of student samples. There is evidence that the nature of emotional experience may differ between young adults and older adults (Carstensen, Isaacowitz, & Charles, 1999). Older adults have been shown to be less variable

than younger adults in their affect ratings in a daily diary study (Röcke et al., 2009) and have also displayed differing relationships between affect and stress from a sample of younger adults (Stawski et al., 2008). The affect structure found in these two samples of younger adults cannot be assumed to be equivalent in older adults or other populations that may differ in fundamental ways. Factorial invariance testing of the multilevel structure of PA and NA among younger and older adults would provide an empirical test of the differences and similarities in the emotional experience of younger and older adults.

A second area that could be of future interest was the time-frame that the daily measures of PA and NA covered. The PANAS was administered in this sample as a 24 hour retrospective measure. Asking participants to report their emotional experience from the previous 24 hour period requires them to aggregate their experiences during that time. Even though this provides a within-person factor structure, it is not a momentary assessment of emotional experience. The correlation observed at the within-person level indicates that experiencing PA and NA are inversely related at the same occasion, the occasion spans over a 24 hour period, during which time individuals may have experienced a wider range of both positive and negative emotions, but not necessarily at the exact same time. This may be a potential reason for the moderately sized correlation. It is possible that had the measurement been more frequent and asked only about momentary affect, then this type of design may find a much stronger within-person correlation, or even potentially that a single, bipolar factor does adequately reflect PA and NA at the same moment. The implementation of an ecological momentary assessment design could investigate such a possibility.

Insight into why PA and NA are independent at the between-person level is still understudied. It may be that there are subsets of individuals who have greater emotional range and have greater variety of emotional experience (both PA and NA), whereas others have less emotional flexibility (e.g., Rast et al., 2012; Röcke et al., 2009). Examining the profiles of emotional experiences through mixture models may give insight into the between-person (individual) differences in the between-person relationship between PA and NA factors.

Conclusions

Among variables that display considerable within-person variations, it is critical to account for both the within-person and between-person structure. Relying on cross-sectional data and neglecting to account for within-person variation could contaminate the between-person factor structure of our measures and lead to inconsistent results, as was the case with the PANAS. When both the within-person and between-person factor structures were modeled, it was clear that the PANAS was best represented by two factors reflecting PA and NA, which differ in their relationship at the within-person and between-person level. The factors are inversely correlated at the within-person level and are independent at the between-person level. The multilevel factor model in combination with intensive repeated measures designs provide the opportunity to better examine the quality and factor structure of many scales that have been predominantly evaluated via cross-sectional studies, but do indeed show considerable within-person variation. Scientific and clinical evaluation of the impact of treatment and contextual effects for optimizing clinical outcomes relies on valid and reliable

assessment at both the within-person and between-person levels of measurement. The PANAS is one example of a scale that shows strong psychometric properties at both the within-person and between-person levels and can be utilized to capture the distinct facets of PA and NA.

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Figure 1.

(a) One within-person factor, one between-person factor (Model 1A); (b) One within-person factor, two independent between-person factors (Model 2A).

Note. Broken line between factors indicates parameter was fixed to zero.

Figure 2.

(a) Two independent within-person and between-person factors (Model 3A); (b) Two correlated within-person and between-person factors (Model 4A); (c) Two correlated within-person factors, independent between-person factors (Model 5A).

Note. Broken lines between factors indicate parameters were fixed to zero.

Figure 3.

Standardized factor loadings and correlations for Model 4B.

Note. Sample 2 values are italicized. Bold values indicate non-significant factor correlations ($p > .46$). All other values were statistically significant ($p < .001$).

Table 1

Means, Standard Deviations, and Intraclass Correlation Coefficients for Sample 1 and Sample 2

Item	Sample 1			Sample 2		
	Mean	SD	ICC	Mean	SD	ICC
1. Interested ^a	3.23	1.09	.49	2.93	1.00	.28
2. Attentive ^a	2.76	1.06	.46	2.88	1.01	.34
3. Alert ^a	2.55	1.10	.47	2.77	1.03	.34
4. Excited ^b	3.14	1.20	.37	2.88	1.12	.28
5. Enthusiastic ^b	2.92	1.18	.43	2.85	1.10	.31
6. Inspired ^b	2.49	1.20	.46	2.44	1.11	.37
7. Strong ^c	2.65	1.06	.48	2.63	1.09	.41
8. Active ^c	2.69	1.15	.44	2.72	1.17	.29
9. Proud ^d	2.59	1.19	.44	2.55	1.15	.34
10. Determined ^d	3.11	1.12	.48	2.98	1.09	.29
11. Distressed ^e	2.52	1.19	.37	1.78	1.04	.30
12. Upset ^e	2.14	1.17	.25	1.68	0.99	.25
13. Guilty ^f	1.72	1.06	.51	1.49	0.87	.34
14. Ashamed ^f	1.51	0.87	.46	1.38	0.78	.42
15. Hostile ^g	1.54	0.89	.46	1.33	0.71	.40
16. Irritable ^g	2.29	1.16	.40	1.72	0.92	.29
17. Jittery ^h	1.98	1.06	.38	1.69	0.98	.31
18. Nervous ^h	2.59	1.24	.40	2.01	1.10	.24
19. Scared ⁱ	1.72	1.01	.46	1.46	0.87	.37
20. Afraid ⁱ	1.74	1.01	.43	1.46	0.88	.39

Note. ICC = intraclass correlation coefficient.

^aCommon letters belong to same mood content category.

^bCommon letters belong to same mood content category.

^cCommon letters belong to same mood content category.

^dCommon letters belong to same mood content category.

^eCommon letters belong to same mood content category.

^fCommon letters belong to same mood content category.

^gCommon letters belong to same mood content category.

^hCommon letters belong to same mood content category.

ⁱ Common letters belong to same mood content category.

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Table 2

Fit Indices for Multilevel CFA Models of the PANAS (Sample 1 | Sample 2)

Model	χ^2 (df)	χ^2_b (df)	CFI	SRMR (WP)	SRMR (BP)	RMSEA
1A One WP factor, one BP factor	3253.03 4768.87 (340)		.519 .506	.149 .154	.336 .347	.083 .089
1B One WP factor, one BP factor ^a	1733.77 2449.67 (314)	1749.35 2618.99 (26)	.765 .762	.105 .127	.263 .292	.061 .064
2A One WP factor, two independent BP factors	2761.04 4262.33 (340)		.600 .562	.120 .143	.101 .077	.076 .084
2B One WP factor, two independent BP factors ^a	1423.29 2159.85 (314)	1237.50 1908.57 (26)	.817 .794	.102 .126	.093 .070	.054 .060
3A Two independent WP factors, two independent BP factors	1644.42 1843.40 (340)		.784 .832	.089 .083	.100 .074	.056 .052
3B Two independent WP, two independent BP factors ^a	879.54 980.83 (314)	665.19 677.82 (26)	.907 .926	.081 .076	.091 .066	.038 .036
4A Two correlated WP factors, two correlated BP factors	1593.74 1818.53 (338)		.792 .835	.068 .070	.093 .074	.055 .052
4B Two correlated WP factors, two correlated BP factors ^a	800.40 950.03 (312)	694.25 659.82 (26)	.919 .929	.054 .060	.082 .066	.036 .035
5A Two correlated WP factors, two independent BP factors	1593.50 1821.24 (339)		.793 .835	.068 .070	.100 .074	.055 .052
5B Two correlated WP factors, two independent BP factors ^a	800.85 951.42 (313)	698.76 664.31 (26)	.919 .929	.054 .060	.091 .066	.036 .035

Note. χ^2 = scaled chi-square difference test comparing B model to A model; CFI = comparative fit index; SRMR = standardized root mean square residual; RMSEA = root mean square error of approximation; WP = within-person; BP = between-person.

^a B models permitted correlated specific factors according to Zevon and Tellegan's mood categories.

^b All values were statistically significant ($p < .001$).

Table 3
Means, Standard Deviations, Reliability, and Intercorrelations of Predictor Variables Aggregated across Occasions

Variable	Sample 1					Sample 2				
	M	SD	$\omega_{wp/bp}$	Correlation		M	SD	$\omega_{wp/bp}$	Correlation	
				1	2				1	2
1 Cognitive Interference	1.83	0.60	.83/.92			1.83	0.63	.84/.96		
2 Daily Stressor	0.79	0.22	—	.30*		0.59	0.25	—	.18*	
3 Physical Symptoms	3.88	2.59	.62/.79	.33*	.21*	—	—	—	—	—
4 Physical Activity	—	—	—	—	—	0.47	0.29	—	-.11*	-.01

Note. $\omega_{wp/bp}$ = within-person reliability/between-person reliability.

* $p < .001$.

Table 4

Estimates from Multilevel SEM Examining the Effects of Cognitive Interference, Stress, Physical Symptoms, and Physical Activity on PA and NA Factors

Affect	Cognitive Interference			Daily Stressor			Physical Symptoms			Physical Activity		
	Sample 1 ^a	Sample 2 ^b		Sample 1 ^a	Sample 2 ^b		Sample 1 ^a	Sample 2 ^b		Sample 1 ^a	Sample 2 ^b	
	Est. (SE)	Est. (SE)		Est. (SE)	Est. (SE)		Est. (SE)	Est. (SE)		Est. (SE)	Est. (SE)	
<i>PA</i>												
Within	-.23(.04) ***	-.23(.04) ***		-.11(.05) *	-.15(.03) ***		-.03(.01) **	—		—	0.29(.04) ***	
<i>R</i> ²	.069	.076		.006	.015		.016				.052	
Between	-.26(.01) **	-.14(.07) *		-.33(.21)	-.12(.18)		-.06(.02) **	—		—	0.70(.14) ***	
<i>R</i> ²	.074	.038		.017	.005		.077				.204	
<i>NA</i>												
Within	0.61(.05) ***	0.57(.04) ***		0.60(.07) ***	0.40(.06) ***		0.06(.02) ***	—		—	-.14(.04) **	
<i>R</i> ²	.312	.351		.099	.074		.037				.009	
Between	0.43(.08) ***	0.55(.08) ***		0.62(.24) *	0.04(.21)		0.08(.02) ***	—		—	-.37(.14) *	
<i>R</i> ²	.248	.449		.071	<.001		.192				.046	

Note. Individual differences in Age and Sex included as covariates in all models. Est. = unstandardized coefficient; PA=positive affect; NA=negative affect.

***
p<.001

**
p<.01

*
p<.05.

^aResults based on 1233 observations (N=179).

^bResults based on 1644 observations (N=147).