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On the Relationship Between Positive and Negative Affect: Their Correlation and Their Co-Occurrence

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Understanding the nature of emotional experience requires understanding the relationship between positive and negative affect. Two particularly important aspects of that relationship are the extent to which positive and negative affect are *correlated* with one another and the extent to which they *co-occur*. Some researchers have assumed that weak negative correlations imply greater co-occurrence (i.e., more mixed emotions) than do strong negative correlations, but others have noted that correlations may imply very little about co-occurrence. We investigated the relationship between the correlation between positive and negative affect and co-occurrence. Participants in each of 2 samples provided moment-to-moment happiness and sadness ratings as they watched an evocative film and listened to music. Results indicated (a) that 4 measures of the correlation between positive and negative affect were quite highly related to 1 another; (b) that the strength of the correlation between measures of mixed emotions varied considerably; (c) that correlational measures were generally (but not always) weakly correlated with mixed emotion measures; and (d) that bittersweet stimuli consistently led to elevations in mixed emotion measures but did not consistently weaken the correlation between positive and negative affect. Results highlight that the correlation between positive and negative affect and their co-occurrence are distinct aspects of the relationship between positive and negative affect. Such insight helps clarify the implications of existing work on age-related and cultural differences in emotional experience and sets the stage for greater understanding of the experience of mixed emotions.

Keywords: mixed emotions, mixed feelings, ambivalence, structure of affect, emotional complexity

Understanding the nature of emotional experience requires understanding the relationship between positive and negative affect. There has been considerable theoretical debate about two particular aspects of this relationship: the extent to which positive and negative affect are *correlated* with one another and the extent to which they *co-occur*. The correlation between positive and negative affect and their co-occurrence may seem indistinguishable, as indicated by Zelenski and Larsen's (2000) suggestion that correlations "can be interpreted as indicating the extent to which, on average, two emotions tend to co-occur" (p. 188). In fact, however, both mathematical realities and hypothetical data indicate that strong inferences about co-occurrence (i.e., mixed emotions) cannot be drawn from correlations (Diener & Iran-Nejad, 1986; Russell & Carroll, 1999). Such recognition has prompted the development of measures of co-occurrence (e.g., Schimmack, 2001), but surprisingly little is known about whether the correlation between positive and negative affect is related to their co-occurrence. Moreover, little is known about the convergent validity of different measures of the correlation between positive and negative affect (e.g., Pearson's r vs. Spearman's ρ) and among different measures of their co-occurrence. We conducted an empirical investigation to shed light on these relationships.

Assessing the Correlation Between Positive and Negative Affect

Most work on the relationship between positive and negative affect involves determining the correlation between different pairs of emotions. More specifically, most of the work involves measuring the linear correlation between pairs of emotions with Pearson's r (e.g., Watson, Clark, & Tellegen, 1988) or coefficients

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derived from hierarachical linear modeling (Rafaeli, Rogers, & Revelle, 2007). This makes considerable sense because the linear correlation typically conveys more information about the relationship between two variables than any other aspect of their relationship does. Moreover, correlation matrices can be submitted to factor analysis to uncover the dimensions underlying emotional experience. Factor analyses have been informative by indicating that the seemingly bewildering array of affective states that people experience can be fairly well characterized in terms of only two dimensions (Remington, Fabrigar, & Visser, 2000; Russell, 1980; Watson & Tellegen, 1985). Moreover, Watson and Tellegen's (1985) finding that high-arousal positive and negative affective states (i.e., positive and negative activation; Watson, Wiese, Vaidya, & Tellegen, 1999) are largely uncorrelated gave rise to the development of the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988), which is by far the most frequently used measure of affective states in the field of psychology.

Polychoric Correlations

One limitation of relying on Pearson's *r* is that interpreting *r* requires assumptions about normality that distributions of affect ratings rarely meet. For instance, ratings of individual emotion items tend to be positively skewed (Schmukle & Egloff, 2009) and pairs of emotion items fail to meet bivariate normality. Bivariate distributions of opposite-valence emotions are particularly problematic because many opposite-valence emotions rarely co-occur (e.g., happiness and sadness, Russell & Carroll, 1999) and almost never co-occur at high intensity (Diener & Iran-Nejad, 1986). Thus, bivariate distributions of positive and negative affect typically approximate an L-shaped distribution (Russell & Carroll, 1999), which means that Pearson's *r* might misrepresent the linear association between positive and negative emotions.

Schmukle and Egloff (2009) suggested that the two *latent* variables underlying ratings of opposite-valence emotions such as happiness and sadness might be linearly related to one another even though *ratings* of those emotions are not linearly related. On this assumption, they advocated the use of polychoric correlations, which estimate linear relationships "between two latent continuous variables underlying . . . manifest categorical variables" (Schmukle & Egloff, 2009, p. 277). Their confirmatory factor analyses indicated that polychoric correlations yielded less biased estimates of the linear relationship between happiness and sadness than do Pearson's *r*s. One limitation of using polychoric correlations is that most theorists agree that even at the latent level polar opposite emotions conform to the L-shaped distribution (Brehm & Miron, 2006; Russell & Carroll, 1999) or at least typically do so (Larsen et al., 2001). Schmukle and Egloff (2009) interpreted their goodness of fit measures as evidence that the latent opposite-valence emotions were linearly related to one another, but it is unclear how goodness of fit measures could provide such evidence. Any nearly L-shaped distribution that could arise from two perfectly negatively correlated latent dimensions could also arise from two mutually exclusive latent dimensions.

Nonparametric Correlational Measures

Nonparametric measures of association, which make no assumptions about whether variables are linearly related to one another, may provide useful alternatives for assessing the relationship between opposite-valence emotions. One straightforward statistic would be Spearman's ρ (i.e., *rho*), which is the rank-order counterpart of Pearson's *r*. A lesser-known alternative is Goodman and Kruskal's (1963) γ (i.e., *gamma*). Calculating γ entails determining the percentage of pairs of observations that are concordant (i.e., the observation with the larger score on the predictor variable also has a larger score on the criterion variable) versus discordant (i.e., the observation with the larger score on the predictor has a smaller score on the criterion; Conover, 1999). Distributions containing more discordant than concordant pairs yield negative γ correlations.

Co-Occurrence of Positive and Negative Affect

Correlational measures (e.g., *r,* polychoric correlations, ρ, γ) can assess how changes in positive affect are related to changes in negative affect, but may not be useful for assessing other aspects of the relationship between positive and negative affect. This is noteworthy because some contemporary models make competing claims about whether such polar opposite emotions as happiness and sadness can co-occur (e.g., Larsen et al., 2001; Russell & Carroll, 1999). Positive correlations between two emotions do imply that they co-occur frequently, but strong negative correlations do not imply less frequent co-occurrence (cf. Zelenski & Larsen, 2000). In fact, correlations will only approach −1 if all observations fall within the vicinity of a line (or, in the case of polychoric and nonparametric correlations, a monotonic curve) extending from some degree of exclusive negative affect to some degree of exclusive positive affect and most of that region includes states comprised of some amount of *both* positive and negative affect (see Figure 1's left panel). As a result, correlations approaching −1 can actually reflect a great deal of co-occurrence (Russell & Carroll, 1999; Schimmack, 2001).

Moreover, the correlation between positive and negative affect for an individual who experiences no mixed emotions (i.e., one who's affective state always falls within the L-shaped, shaded region of Figure 1's right panel) need not approach −1 (Russell & Carroll, 1999). If, for instance, observations were uniformly dis-

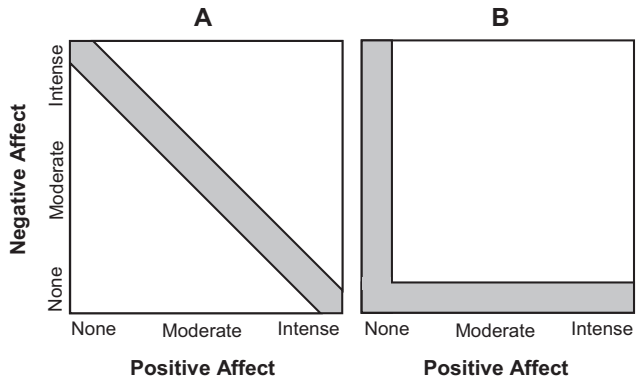

Figure 1. Two nonexhaustive possible relationships between positive and negative affect. If all observations fall within Panel A's shaded area, the correlation between positive and negative affect will meet or approach −1 but the incidence of mixed emotions can vary. If all observations fall within Panel B's shaded area, the incidence of mixed emotions will be low but the correlation between positive and negative can vary from −1 to nearly 0.

tributed throughout the L-shaped region, the correlation would be approximately −.60 (Schimmack, 2001). Even correlations approaching 0 need not imply a great deal of co-occurrence if there is a restriction in range in positive affect, negative affect, or both.

Despite such ambiguity, researchers often make inferences about co-occurrence from correlations (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000; Leu et al., 2010; Ong & Bergeman, 2004; Shiota, Campos, Gonzaga, Keltner, & Peng, 2010). The first and second authors have been among these researchers. Larsen and McGraw (2011) interpreted Andrade and Cohen's (2007) finding that moment-to-moment ratings of happiness and fear during a horror film were negatively correlated among nonfans as evidence that nonfans experienced less mixed emotions during the film than fans did. In addition, Hershfield, Scheibe, Sims, and Carstensen (2013) interpreted the finding that weaker negative correlations between positive and negative were associated with health outcomes as evidence that mixed emotions were associated with better health.

MIN

In light of the limitations of using correlations to assess co-occurrence, Schimmack (2001) developed a direct measure of co-occurrence. Drawing on measures of attitudinal ambivalence (Kaplan, 1972), Schimmack indexed mixed emotions as the smaller of a given observation's positive and negative affect ratings (i.e., MIN [positive affect, negative affect]). Thus, whereas occasions in which positive and negative affect are mutually exclusive (or both are absent) yield scores of 0, occasions in which both occur yield higher scores. Similar approaches represent dichotomized versions of MIN. Two of these approaches include determining whether at a given time participants reported any amount of both positive and negative affect at a given time (Folkman & Lazarus, 1985; Russell & Carroll, 1999) or amounts that met or exceeded the scale midpoint (Smith & Ellsworth, 1987).

Mean-Based Co-Occurrence Measure

One limitation of MIN is that acquiescence biases can lead to inflated MIN scores (Larsen et al., 2001), as can preference for moderate responses (I. Grossman, personal communication, October 2014). Riediger, Schmiedek, Wagner, and Lindenberger (2009) developed a measure that mitigates the effects of such response biases. They indexed frequency of co-occurrence as the proportion of episodes during which each participant reported levels of both positive and negative affect that were at least as intense as the participant's own mean level of positive and negative affect, respectively. Thus, individuals with large acquiescence biases would only receive high co-occurrence scores on this *mean-based co-occurrence measure* if they frequently reported especially intense levels of both positive and negative affect.

In that positive and negative affect rarely co-occur at high levels (Diener & Iran-Nejad, 1986), the mean-based measure may not be as sensitive as MIN. Other factors may also reduce the sensitivity of mean-based co-occurrence scores. Consider two hypothetical people who begin a month-long experience sampling study on the day they graduate from college. They both experience somewhat bittersweet feelings that day and thereby report modest amounts of co-occurrence. If one individual spends the rest of the month experiencing and reporting little emotion, then the first day's observations will be scored as instances of co-occurrence and the remainder will not. This makes sense. If the other individual spends the rest of the month on vacation experiencing and reporting a great amount of positive affect, the first day's positive affect will fall below the mean. As a result, the initial observations will not be scored as instances of co-occurrence even though positive and negative affect had co-occurred.

Residualized MIN

Grossman, Huynh, and Ellsworth (in press) provided another approach to controlling for response biases. They conducted a regression in which they predicted participants' mean MIN rating on the basis of the mean of their combined positive and negative affect ratings. Participants' residuals were used to index co-occurrence, such that higher residuals reflected greater co-occurrence. This approach penalizes individuals who typically report experiencing intense affect. The *residual MIN* measure is similar to the mean-based measure, but there are differences. Most noteworthy, observations can contribute to higher residualized MIN scores to varying degrees. For instance, observations in which the participant reported some co-occurrence could contribute to higher residualized MIN scores even if positive (and/or negative) affect fell below the mean positive (and/or negative) affect.

There are at least two limitations of residualized MIN scores. First, we would expect two individuals who never reported mixed emotions to receive comparably low scores. Nonetheless, the one who typically reported less intense emotions will receive a higher residualized MIN score. Second, residualized MIN scores cannot be calculated for each observation; they can only be calculated for aggregates of observations (e.g., all observations provided by a given participant). As a result, residualized MIN scores can identify *who* reported the most co-occurrence, but cannot pinpoint *when* they reported co-occurrence.

The Current Study

The extent to which positive and negative affect are correlated versus co-occur represent conceptually distinct aspects of their relationship; furthermore, hypothetical distributions indicate that they can also be empirically distinct (Russell & Carroll, 1999; Schimmack, 2001). It is unknown whether correlational and co-occurrence measures derived from data gathered from actual people will be distinct. It is also unknown how strongly related the various correlational measures (e.g., r, ρ) are with one another. Evidence that they are strongly correlated with one another would provide convergent validity and assuage concerns about each of their potential limitations (e.g., violation of r's distributional assumptions; MIN's susceptibility to response biases). Similarly, evidence that the various co-occurrence measures are strongly related to one another would speak to their convergent validity.

We derived correlational and co-occurrence measures from participants' moment-to-moment ratings of their happiness and sadness.[1] In

[1] This study was designed to investigate individual differences in mixed emotions (Stastny, 2011). We later realized that they allowed us to investigate the relationship between Pearson's r and MIN. We had few a priori predictions and took a data-driven approach to analyzing and interpreting the results. During the review process, action editor Ulrich Schimmack encouraged us to cast a wider net by including other correlational measures. We also included other co-occurrence measures.

order to investigate generalizability across tasks, we had all participants go through two emotion inductions. Participants watched scenes from the tragicomic film *Life Is Beautiful* that have been shown to elicit positive, negative, and mixed emotions (Larsen & Green, 2013; Larsen & McGraw, 2011; Larsen, McGraw, & Cacioppo, 2001). In another task, participants listened to a series of brief musical excerpts. Some music can make people sad, particularly pieces that feature slow tempos and/or patterns of pitch changes characteristic of minor modes (e.g., Webster & Weir, 2005). Even so, even saddening music contains properties that elicit happiness (e.g., high pitch, consonance, smooth rhythm; see Juslin & Laukka, 2004) and people are most likely to mention happiness when they are asked to indicate the feelings that they experience while listening to music (Juslin & Laukka, 2004). As a result, MIN scores have revealed that pieces that are slow and/or in the minor mode elicit more intense mixed emotions than do fast, major mode pieces (Hunter, Schellenberg, & Schimmack, 2008, 2010; Larsen & Stastny, 2011).[2]

Method

Participants

Two samples of participants completed nearly identical procedures. The only substantive difference is that Sample 1's participants rated their happiness and sadness on 5-point scales and Sample 2's participants did so on 251-point scales.

Sample 1. Participants were 104 Texas Tech undergraduates who completed the study in exchange for course credit in introductory psychology ($n = 93$) or a chance to win one $100 prize ($n = 11$). Film task data from six participants (6%) were lost due to computer error. Music task data from one participant (1%) who failed to complete the task and three participants (3%) who appeared to respond randomly were removed.[3] The final dataset included film task data from 98 participants (48% women) and music task data from 100 participants (49% women).

Sample 2. Participants were 110 Texas Tech undergraduates who completed the study in exchange for course credit in introductory psychology. All data from three participants (3%) were lost due to computer error, as were the film task data from another two (2%) participants. Data from two (2%) additional participants in each task were removed because they appeared to respond randomly. The final dataset included film task data from 103 participants (72% women) and music task data from 105 participants (71% women).

Procedure

Upon arrival, participants listened to a description of the study. After completing a number of individual differences measures,[4] participants received extensive instructions for using a 5 × 5 (Sample 1) or 251 × 251 (Sample 2) version of the moment-to-moment evaluative space grid (Larsen, Norris, McGraw, Hawkley, & Cacioppo, 2009; see Figure 2). The evaluative space grid allowed participants to report how happy and how sad they felt by moving the computer cursor along the horizontal and vertical axes of a two-dimensional grid, respectively. The computer recorded the cursor's location within the grid every 500 ms.

Film task. Participants watched Larsen and Green's (2013) 23-min subtitled clip from *Life Is Beautiful*, a tragicomic Italian film set in a World War II concentration camp. (The grid appeared below the film near the bottom of the screen.) Scattered throughout the clip were 5-s segments that typically elicit exclusive happiness, exclusive sadness, and mixed emotions of happiness and sadness, as indexed by MIN scores (Larsen & Green, 2013). Each of these categories contained five segments and therefore 25 s (i.e., 50 samples) of footage.

Music task. Participants listened to the 48 musical excerpts provided by Hunter, Schellenberg, and Schimmack (2008), each of which is 30-s long. (The grid appeared near the bottom of the otherwise blank screen.) The pieces come from a range of genres (e.g., classical, jazz, pop, and world music) and include 12 pieces from each of the four categories formed by crossing fast versus slow tempo with major versus minor mode (e.g., 12 fast pieces in major modes; see Hunter et al., 2008, for a complete list).

Recalled emotions. After completing the music task, participants were asked to complete a pencil-and-paper measure assessing how well they remembered their positive, negative, and mixed emotions. They first estimated the percentage of time they felt neutral, exclusively good, exclusively bad, or mixed during each of the two tasks. They then estimated how good, bad, and mixed they felt during those times in which they felt good, bad, and mixed, respectively, on 7-point scales ranging from 0 (*not at all*) to 6 (*extremely*). One of Sample 1's participants (1%) neglected to provide these ratings, as did three of Sample 2's participants (3%).

[2] Both Hunter et al. (2008, 2010) and Larsen and Stastny (2011) focused on whether music is more likely to elicit mixed emotions when tempo and mode are in conflict (e.g., fast tempo and minor mode) than when they are consistent with one another (e.g., fast tempo and major mode). This focus makes sense in light of the finding that mode and tempo had interactive effects on MIN scores in all of their studies. Nevertheless, that focus overlooks evidence that slow tempos elicit more mixed emotions than fast tempos (Hunter et al., 2008, 2010) and that minor modes elicit more mixed emotions than major modes (Larsen & Stastny, 2011). The most complete and parsimonious explanation for the data is that music generally makes people feel happy (see Juslin & Laukka, 2004) and that the happiness elicited by music that is slow and/or in the minor mode can be accompanied by sadness.

[3] For each task within each sample, random responders were identified by computing the correlation between each participant's moment-to-moment bipolar emotion scores (i.e., happiness–sadness) collected throughout the task and the average participant's moment-to-moment bipolar emotion scores. Participants whose correlations were at least 3 *SD* below the mean were treated as random responders.

[4] Participants completed the Dialectical Self Scale (Spencer-Rodgers, Peng, & Wang, 2010), Analysis-Holism Scale (Choi, Koo, & Choi, 2007), Preference for Consistency Scale (Cialdini, Trost, & Newsom, 1995), the Need for Closure Scale (Webster & Kruglanski, 1994), and the Center for Epidemiological Studies-Depression Scale (CESD; Radloff, 1977). Participants in Samples 1 and 2 also completed the Need for Cognition Scale (Cacioppo, Petty, & Kao, 1984) and Revised Life Orientation Test (Scheier, Carver, & Bridges, 1994), respectively. Stastny (2011) reported many individual differences analyses from Sample 1 and analyses from both samples will be reported more fully elsewhere. Note that a syntax error invalidated the Need for Closure and Need for Cognition analyses reported by Stastny.

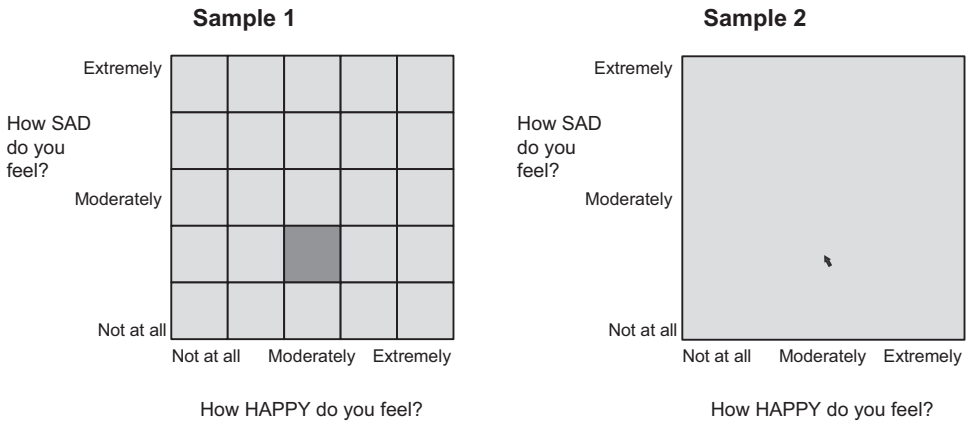

Figure 2. The 5 × 5 and 251 × 251 versions of the evaluative space grid used by participants in Samples 1 and 2, respectively (adapted from Larsen et al., 2009). Participants used the computer mouse to move the cursor within the grid. The cursor's location was represented by a dark box in the 5 × 5 grid and a pointer in the 251 × 251 grid. The computer collected moment-to-moment ratings of happiness and sadness by recording the cursor's location every 500 ms.

Results

Calculation of Co-Occurrence and Correlational Measures

Each participant provided 2,786 pairs of happiness and sadness ratings during the film task and another 2,880 pairs during the music task. For each participant, we assessed co-occurrence by calculating mean MIN scores, mean-based co-occurrence, and residualized mean MIN scores. We also assessed the linear correlation between positive and negative affect in several ways. SPSS was used to compute r and ρ.[5] SAS's FREQ PROC was used to estimate polychoric correlations and compute γ. Sample 2's scale contained too many categories to assess polychoric correlations and γ, so we transformed these data from the original 251-point scale to a 5-point scale by converting values ranging from 0 to 49 to 0, 50 to 99 to 1, and so forth. Nonetheless, SAS was unable to compute γ from the film task data provided by one (1%) of Sample 2's participants. It was also unable to estimate polychoric correlations from the film task data provided by three (3%) of Sample 1's participants and 14 (14%) of Sample 2's. Descriptive statistics are shown in Table 1.

Convergent Validity

Correlations between co-occurrence and correlational measures are shown in Tables 2 and 3, respectively. Co-occurrence scores were often J-shaped with a mode of zero (see also, Larsen & Green, 2013; Larsen & McGraw, 2011), so we relied entirely on nonparametric measures of association (e.g., ρ in lieu of r). Correlations among co-occurrence measures tended to be fairly strong (ρ = .61) but varied considerably (range = .22–.85). This pattern of correlations suggests that all three measures assess co-occurrence to some degree, but are each uniquely sensitive to other sources of variance (e.g., response biases). Correlations among the correlational measures were quite strong (ρ = .85) and many approached 1.0 (range = .50–.99). These results indicate that even though affect ratings violate distributional assumptions, both parametric (i.e., r, polychoric correlations) and nonparametric (i.e., ρ, γ) correlational measures assess the correlation between positive and negative affect equally well.

Relationships Between the Co-Occurrence of and Correlation Between Happiness and Sadness

Correlations between the correlational and co-occurrence measures are shown in Table 4. MIN (the most-commonly used co-occurrence measure) was never significantly correlated with either r (the most-commonly used correlational measure) or ρ (ρ = −.08 to 12). On the other hand, MIN scores were correlated with polychoric correlations in three cases (ρ = −.01 to −.26) and with γ in all four cases (ρ = .26 to .59). Moreover, the other two co-occurrence measures were consistently correlated with all four correlational measures, sometimes quite strongly. Mean-based co-occurrence scores were associated with each correlational measure in all four cases (ρ = .25 to .73). Correlations involving residualized MIN scores were comparably strong (ρ = .18 to .75). Thus, participants who reported especially high levels of both happiness and sadness on numerous occasions showed weaker negative/stronger positive correlations between happiness and sadness. Even so, the correlations between co-occurrence and correlational measures (see Table 4) were considerably lower (M = .38, SD = .23) than those between different co-occurrence measures (see Table 2; M = .61, SD = .18); $t(58)$ = −3.54, d = −1.14, and different correlational measures (see Table 3; M = .85; SD = .16); $t(70)$ = −10.70, d = 2.68, thereby demonstrating the discriminant validity of both types of measures.

[5] Pearson's r values are shown in figures and tables, but statistical analyses were conducted on Fisher-transformed r values.

Table 1
Mean Happiness and Sadness Scores, Co-Occurrence Scores, and Correlations

	Film task				Music task			
	Sample 1		Sample 2		Sample 1		Sample 2	
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Raw scores								
Happiness	.98	.58	50.8	25.1	1.22	.48	71.0	31.0
Sadness	1.60	.82	105.0	50.0	.63	.45	33.3	21.6
Co-occurrence								
MIN	.41	.36	17.4	17.6	.34	.33	13.2	11.4
Mean-based	.12	.14	.07	.08	.14	.10	.09	.07
Residualized MIN	.00	.27	.0	15.0	.00	.16	.0	7.5
Correlational								
Pearson's *r*	−.38	.33	−.51	.23	−.12	.27	−.25	.24
Polychoric correl.	−.46	.43	−.65	.29	−.18	.39	−.40	.36
Spearman's ρ	−.38	.34	−.50	.26	−.11	.27	−.18	.28
γ correlation	−.49	.48	−.74	.30	−.18	.42	−.51	.46

Differential Effects of Scene and Music Type on Co-Occurrence and Correlational Measures

We also investigated how variables that have influenced MIN scores in prior research influenced co-occurrence and correlational measures in the current study. First, we investigated emotional reactions during the pleasant, unpleasant, and bittersweet scenes of the film clip that were identified by Larsen and Green (2013). Descriptive statistics for raw happiness and sadness ratings during these scenes are shown in Table 5.

We computed co-occurrence and correlational measures during each type of scene with a number of caveats. First, residualized MIN scores were not computed because the mean residualized score for each type of scene would necessarily be 0. Second, correlations could not be calculated during scenes in which participants' happiness and/or sadness did not vary. As a result, 69 participants (70%) in Sample 1 and 20 (19%) participants in Sample 2 lacked a full complement of correlations. Lack of variance in either happiness and/or sadness indicates that there was no relationship between happiness and sadness, so we replaced these missing values with 0. Third, even among participants with variance in both happiness and sadness during all types of scenes, SAS's PROC FREQ was unable to provide full complements of polychoric and γ correlations for many participants in both Sample 1 (polychoric correlations: 37 [38%], γ correlations: 5 [5%]) and Sample 2 (polychoric correlations: 94 [91%], γ correlations: 84 (82%). Given that the number of Sample 2's participants with missing polychoric or γ correlations exceeded 50%, analyses of those data are not reported.

We then conducted a series of Friedman tests to assess the effects of scene on each type of score. We followed up Friedman tests (all of which were significant, $p < .001$) with Wilcoxon's tests in which scores from the bittersweet scenes were compared with scores from each of the other scenes.[6] Replicating Larsen and Green's (2013) findings, both MIN and mean-based co-occurrence scores were higher during bittersweet scenes than during pleasant and unpleasant scenes ($r^2 = .26–.54$; see Figure 3). Correlational measures also revealed a consistent pattern, albeit a different one. In all cases, negative correlations were no weaker during bittersweet scenes than during unpleasant scenes ($r^2 = .00–.02$) and were *stronger* during bittersweet scenes than during pleasant scenes ($r^2 = .28–45$; see Figure 3). One possibility is that differences in the amount of variance in happiness, sadness, or both influenced the magnitude of the negative correlations during different scenes. Standard deviations revealed that there was almost no variance in participants' sadness ratings during the pleasant scenes (see Table 5). Such restriction in range presumably attenuated the negative correlation between happiness and sadness.

We also compared co-occurrence and correlational measures computed from observations gathered during the four different types of music. Descriptive statistics for raw happiness and sadness ratings during each music type are provided in Table 6. As with the film task data, (a) there was no reason to compute residualized MIN scores; (b) correlations that were missing among the 20 participants in Sample 1 (20%) who showed no variance in happiness and/or sadness during one or more types of music were replaced with zero; and (c) SAS was unable to provide full complements of polychoric and γ correlations for many participants in Sample 1 (polychoric correlations: 16 [16%], γ correlations;

Table 2
Correlations (Spearman's ρ) Among Measures of the Co-Occurrence of Positive and Negative Affect

	Film task			Music task		
Measure	1	2	3	1	2	3
1. MIN	—	.65**	.65**	—	.85**	.22*
2. Mean-based	.77**	—	.53**	.73**	—	.37**
3. Residualized MIN	.73**	.70**	—	.50**	.58**	—

Note. Entries above and below the diagonal are from Samples 1 and 2, respectively. MIN = the smaller of a given observation's happiness and sadness ratings.
* $p < .05$. ** $p < .01$.

[6] Friedman and Wilcoxon's tests are the nonparametric analogs to the one-way between-subjects ANOVA and *t* tests, respectively. Following Fritz, Morris, and Richler's (2012), we estimated effect size for Wilcoxon's tests with r^2.

Table 3
Correlations (Spearman's ρ) Among Measures of the Correlation Between Positive and Negative Affect

Measure	Film task				Music task			
	1	2	3	4	1	2	3	4
1. Pearson's *r*	—	.96**	.97**	.91**	—	.97**	.99**	.93**
2. Polychoric correl	.84**	—	.95**	.97**	.87**	—	.98**	.98**
3. Spearman's ρ	.73**	.63**	—	.93**	.93**	.78**	—	.95**
4. γ correlations	.50**	.95**	.50**	—	.62**	.93**	.63**	—

Note. Entries above and below the diagonal are from Samples 1 and 2, respectively.
* $p < .05$. ** $p < .01$.

0 [0%]) and Sample 2 (polychoric correlations: 71 [68%], 53 [50%]). Given that ≥50% of Sample 2's participants had missing polychoric or γ correlations, those analyses are not reported.

The most consistent finding from previous research is that fast major pieces elicit less intense mixed emotions than other types of music, so we followed up Friedman tests (all of which were significant, $p < .001$) with Wilcoxon's tests in which we compared scores from fast major pieces with scores from each of the other three types of pieces. With one exception, both MIN and mean-based co-occurrence scores indicated that fast minor, slow major, and slow minor music elicited more mixed emotions than fast major music ($r^2 = .02$–$.57$; see Figure 4).

In Sample 1, correlational measures yielded fairly similar patterns to those yielded by co-occurrence measures (see Figure 4). Compared with fast major pieces, slow major pieces yielded significantly stronger positive correlations of all types ($r^2 = .18$–$.25$) and fast minor pieces yielded larger polychoric correlations ($r^2 = .10$) and γ correlations ($r^2 = .09$). In Sample 2, patterns of ρ's were fairly similar to those from Sample 1, with slow major pieces yielding stronger positive correlations than fast major pieces ($r^2 = .32$). In contrast, *r*'s from slow major and fast major pieces were comparable ($r^2 = .00$) and slow minor pieces elicited stronger negative *r*'s than did fast major pieces ($r^2 = .11$). It is unclear why these discrepancies emerged.

Predictive Validity of Co-Occurrence Scores and Recalled Mixed Emotions

The questions about people's recall of how often they experienced mixed emotions and their intensity allowed us to investigate whether people with higher co-occurrence scores tended to recall having experienced more mixed emotions (see Aaker, Drolet, & Griffin, 2008). Thus, they allowed us to assess the co-occurrence scores' relative predictive validity. As shown in Table 7, MIN scores were more consistently correlated with the recall measures than mean-based co-occurrence and residualized MIN scores were. These results provide suggestive evidence that MIN scores have greater predictive validity than the other co-occurrence measures.

Discussion

We investigated the relationship between the correlation between positive and negative affect and their co-occurrence. Data from two samples of participants who each completed two evocative tasks generally revealed strong relationships among measures of each aspect (i.e., convergent validity) and weaker correlations among measures of the different aspects. In addition, they showed differential predictive validity, in that bittersweet stimuli consistently led to elevated co-occurrence scores but did not consistently

Table 4
Correlations Among Measures of the Correlation Between Positive and Negative Affect (Pearson's r, Polychoric Correlations, Spearman's Rho, Gamma) and Their Co-Occurrence (MIN, Mean-Based Co-Occurrence, Residualized MIN Scores)

Sample and measure	Film task				Music task			
	r	Polychoric	ρ	γ	*r*	Polychoric	ρ	γ
Sample 1								
MIN	.11	.26*	.11	.26**	.09	.21*	.12	.27**
Mean-based	.45**	.54**	.50**	.57**	.28**	.38**	.31**	.42**
Residualized MIN	.58**	.61**	.54**	.58**	.75**	.74**	.73**	.68**
Sample 2								
MIN	−.08	.32**	.00	.59**	−.14	−.01	−.01	.41**
Mean-based	.25*	.60**	.30**	.73**	.33**	.45**	.40**	.61**
Residualized MIN	.31**	.51**	.18	.49**	.44**	.45**	.50**	.49**

Note. *r* = Pearson's *r*; ρ = Spearman's ρ. MIN = the smaller of a given observation's happiness and sadness ratings.
* $p < .05$. ** $p < .01$.

Table 5
Descriptive Statistics for Happiness and Sadness Ratings During the Film's Bittersweet, Unpleasant, and Pleasant Scenes

	Sample 1				Sample 2			
	Intraindividual *M*		Intraindividual *SD*		Intraindividual *M*		Intraindividual *SD*	
Rating and scene	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Happiness								
Bittersweet	1.58	.79	1.06	.43	86.7	44.6	68.2	26.2
Unpleasant	.56	.61	.60	.38	25.4	24.4	37.1	24.6
Pleasant	1.93	.97	.78	.39	121.3	51.0	45.2	23.0
Sadness								
Bittersweet	1.61	1.00	.82	.44	105.1	59.7	59.7	30.0
Unpleasant	2.06	1.01	1.00	.44	134.1	53.9	69.6	21.6
Pleasant	.26	.50	.25	.36	13.3	29.4	9.6	18.4

Note. Intraindividual *M* and *SD* = the mean and standard deviation of a given participant's ratings, respectively.

produce weaker negative (or stronger positive) correlations between positive and negative affect.

Relationships Among Correlational Measures

In general, measures of the correlation between positive and negative affect were highly correlated with each other, particularly in Sample 1. Indeed, all 20 of Sample 1's correlations were directionally stronger than their Sample 2 counterparts. Increasing the scale points from 5 to 251 presumably weakened the correlations. Sample 1's 5-point scales more closely resemble the typical study than Sample 2's 251-point scales, so Sample 1's stronger correlations are probably more generalizable. Correlations were so high in Sample 1 as to make the various correlational measures virtually interchangeable with one another. All this coupled with the fact that it is already standard practice to use *r* to assess the correlation between positive and negative affect, we recommend researchers continue to do so for most purposes. When it comes to factor analysis, however, Schmukle and Egloff (2009) have provided evidence that polychoric correlations yield more valid estimates of factor loadings than do Pearson's *r*. In that polychoric correlations may not best capture the relationship between positive and negative affect, the development of nonparametric factor analytic techniques (Gershman & Blei, 2012) may be useful.

Relationships Among Co-Occurrence Measures

Different co-occurrence measures were always significantly correlated with one another, but the magnitude of the correlation varied considerably across samples and tasks. It appears that even though all of them assess co-occurrence to some degree, they are also uniquely sensitive to extraneous factors. This raises challenging questions about which is the most valid. Correlations with recalled mixed emotions provided at least some predictive validity for all three measures, most consistently for MIN scores. In future research, another approach to assessing predictive validity will involve asking research participants to indicate how conflicted they feel about evocative stimuli. Mixed emotions elicit feelings of conflict (Cacioppo & Berntson, 1994; Williams & Aaker, 2002), so co-occurrence scores should be correlated with self-reported conflicted feelings. Indeed, strong correlations with conflicted feelings have been used to assess the predictive validity of measures of attitudinal ambivalence (e.g., Priester & Petty, 1996).

In terms of recommendations for those interested in measuring the co-occurrence of positive and negative affect, we suspect that different measures will be more appropriate in different circumstances. MIN is likely to be most sensitive to instances of co-occurrence in which positive or negative affect are only mildly intense, which is an important consideration because mixed emotions rarely co-occur at high intensity (Diener & Iran-Nejad, 1986). If response biases are of concern, however, mean-based co-occurrence or residualized MIN scores may be more informative than MIN scores. One sensible approach is to calculate and report all co-occurrence scores. If our results are any indication, patterns obtained with one co-occurrence score should generalize to others. For instance, both MIN scores and mean-based co-occurrence scores were selectively elevated during the bittersweet scenes identified by Larsen and Green (2013). Thus, regardless of how much consistency there was between measures in terms of who experiences co-occurrence, there was substantial consistency in terms of what types of stimuli elicit co-occurrence.

The Relationship Between Correlational and Co-Occurrence Measures

Our main goal was to investigate the relationship between the correlation between happiness and sadness and their co-occurrence. Estimating the magnitude of that relationship is challenging because the strength of the relationship among measures of co-occurrence varied. Relationships between MIN scores and correlational measures give the impression that the correlation between and co-occurrence of happiness and sadness were largely independent of one another. In contrast, relationships between the other co-occurrence scores (i.e., mean-based co-occurrence, residualized MIN scores) give the impression that the two variables moderately or even strongly associated with one another.

There was a clear disconnect between all types of correlational versus co-occurrence measure when comparing scores during the different scenes, particularly the bittersweet and pleasant scenes. Even though happiness and sadness co-occurred more during the

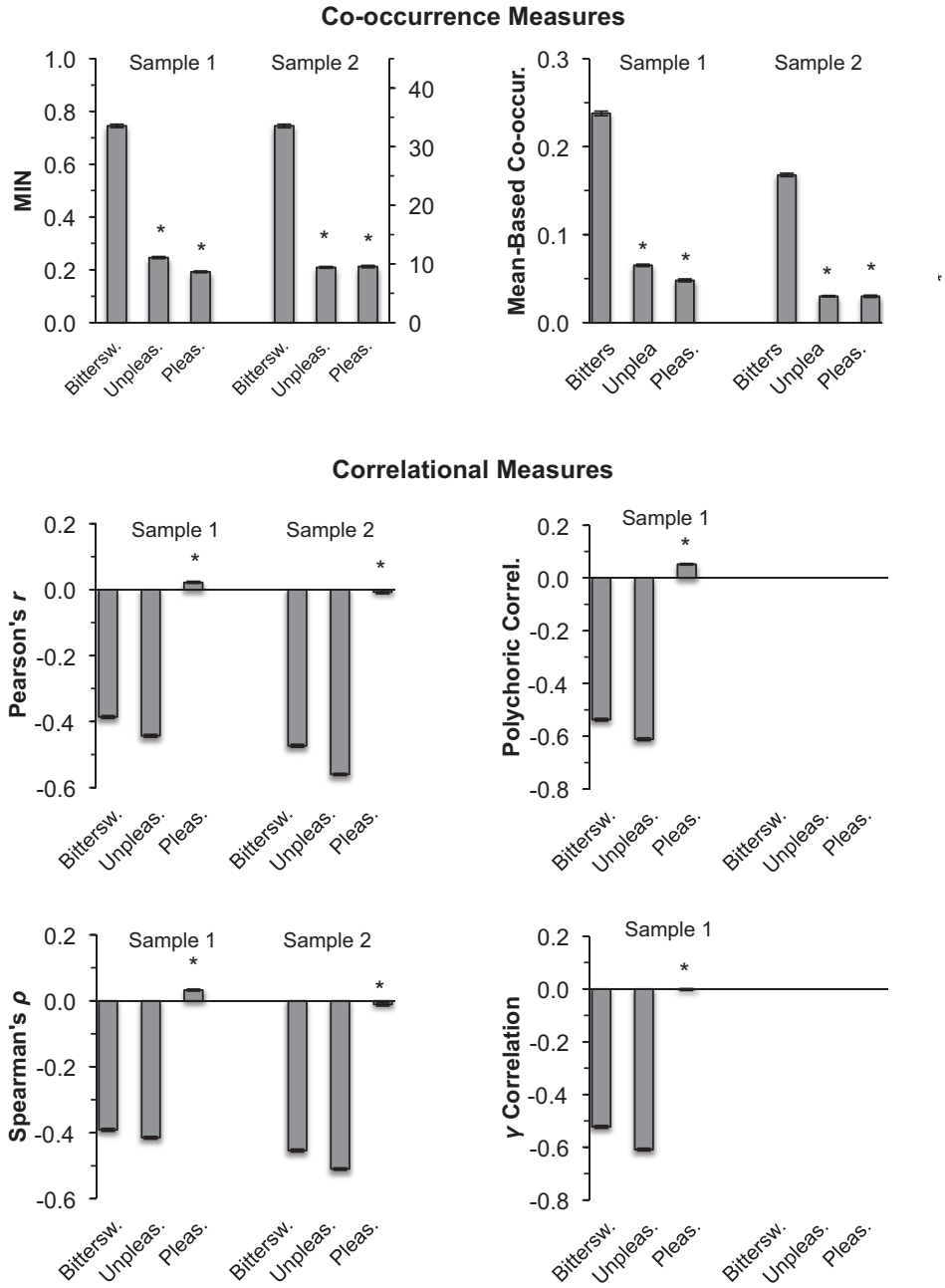

Figure 3. Mean scores on the co-occurrence and correlational measures during the film's bittersweet, unpleasant, and pleasant scenes. Asterisks represent values that differ significantly from the bittersweet scenes at $p = .05/2 = .025$. Due to excessive missing data, Sample 2's polychoric and γ correlations are not shown.

bittersweet scenes, they were also more strongly negatively correlated during those scenes. They were strongly negatively correlated during the bittersweet scenes in part because they both showed considerable variance during those scenes. In contrast, happiness and sadness were uncorrelated during the pleasant scenes in part because there was almost no variance in sadness. The findings that co-occurrence and correlational measures were sometimes independent of one another and showed different patterns during different types of evocative stimuli provide evidence for their discriminant validity. Most important, these findings make clear that inferences about mixed emotions cannot be drawn from measures of the correlation between positive and negative affect (Russell & Carroll, 1999; Schimmack, 2001).

One reason why correlational and co-occurrence measures are imperfectly correlated with one another is that correlations are more sensitive to variance in positive and negative affect.

Table 6
Descriptive Statistics for Happiness and Sadness Ratings During the Different Types of Music

	Sample 1				Sample 2			
	Intraindividual *M*		Intraindividual *SD*		Intraindividual *M*		Intraindividual *SD*	
Rating and music type	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Happiness								
Fast major	1.86	.64	1.12	.28	113.8	45.7	67.3	16.3
Fast minor	1.43	.58	1.05	.27	84.3	39.1	61.0	17.6
Slow major	1.00	.52	.90	.26	55.1	31.1	51.6	18.2
Slow minor	.61	.48	.74	.32	30.7	22.0	42.5	19.9
Sadness								
Fast major	.27	.40	.41	.37	8.9	11.4	16.0	15.4
Fast minor	.43	.47	.53	.36	17.8	16.8	25.6	18.2
Slow major	.75	.56	.71	.30	41.0	30.1	42.9	22.3
Slow minor	1.09	.62	.91	.33	65.6	38.9	57.6	25.4

Note. Intraindividual *M* and *SD* = the mean and standard deviation of a given participant's ratings, respectively.

This has implications for researchers who treat weak correlations between positive and negative affect as evidence for greater *emotional complexity* (e.g., Carstensen et al., 2000). Weak correlations may reflect more complex emotional experiences (e.g., co-occurrence), but they might simply reflect restriction in range. Consider our finding that happiness and sadness were uncorrelated or weakly negatively correlated during pleasant scenes from *Life Is Beautiful* because those scenes elicited virtually no sadness. Rather than interpreting the weak correlations as evidence for emotional complexity, a more accurate statement is that happiness and sadness were uncorrelated because there was nothing complex about emotional reactions to the pleasant scenes.

Implications for Developmental and Cultural Differences in Emotional Experience

We hope that distinguishing between the correlation between positive and negative affect and their co-occurrence will clarify our understanding of individual differences in emotional experience.

Age-Related Differences

Consider differences in emotional experience across the adult life span. In an experience sampling study, Carstensen, Pasupathi, Mayr, and Nesselroade (2000) found weaker negative correlations between positive and negative affect among older adults than younger adults, and Carstensen et al. (2011) found that the negative correlations between positive and negative affect grew weaker over time, within individuals. They interpreted these findings as evidence that older adults experience more mixed emotions than younger adults.[7] Similarly, Hershfield et al. (2013) found that adults whose negative correlations weakened over time showed better health outcomes. They interpreted this finding as evidence that mixed emotions are associated with healthy coping.

In experimental work, Williams and Aaker (2002) found that older adults did feel less conflicted about bittersweet ads, but co-occurrence scores provided no evidence that older adults experienced more mixed emotions per se. During daily life, co-occurrence scores indicate that older individuals experience *less* intense mixed emotions than younger individuals (Riediger et al., 2009; Riediger, Wrzus, & Wagner, 2014), possibly because they are less likely to enjoy experiencing negative emotions (Riediger et al., 2014). While our results indicate that weaker negative correlations may not always reflect more intense mixed emotions, a recent study with thousands of participants, found that older individuals had larger co-occurrence scores and weaker negative correlations than younger adults. In contrast to our results, these authors also found that co-occurrence and correlational indices were positively correlated (r = .30). These findings raise the possibility that mixed emotions and weaker correlations between positive and negative affect may be more closely coupled with one another in daily life than they were in our laboratory study. Schneider and Stone (2015) suggested that both mixed emotions and weaker correlations may each reflect different aspects of successful emotion regulation.

Cultural Differences

At the between-subjects level, those from Asian backgrounds show weaker negative correlations between positive and negative affect than do those from Western backgrounds in classroom settings (Bagozzi, Wong, & Yi, 1999) and after evocative conversations with their romantic partners (Shiota et al., 2010). At the within-subjects level, some evidence indicates that Westerners show relatively strong negative correlations between positive and negative affect (Schimmack, Oishi, & Diener, 2002; but see Scollon, Diener, Oishi, & Biswas-Diener, 2005) and bilingual Asian

[7] Subsequent studies have yielded fairly inconsistent findings. Ong and Bergeman's (2004) results replicated those of Carstensen et al. (2000), but both Gruhn, Lumley, Diehl, and Labouvie-Vief (2013) and Hay and Diehl (2011) found no relationship between age and the correlation between positive and negative affect, and one of Ready, Carvalho, and Weinberger's (2008) studies revealed that older individuals actually showed stronger negative intraindividual correlations than younger individuals did. As Schneider and Stone (2015) note, these differences may be an earlier studies' small sample sizes as well as the reliance on convenience samples.

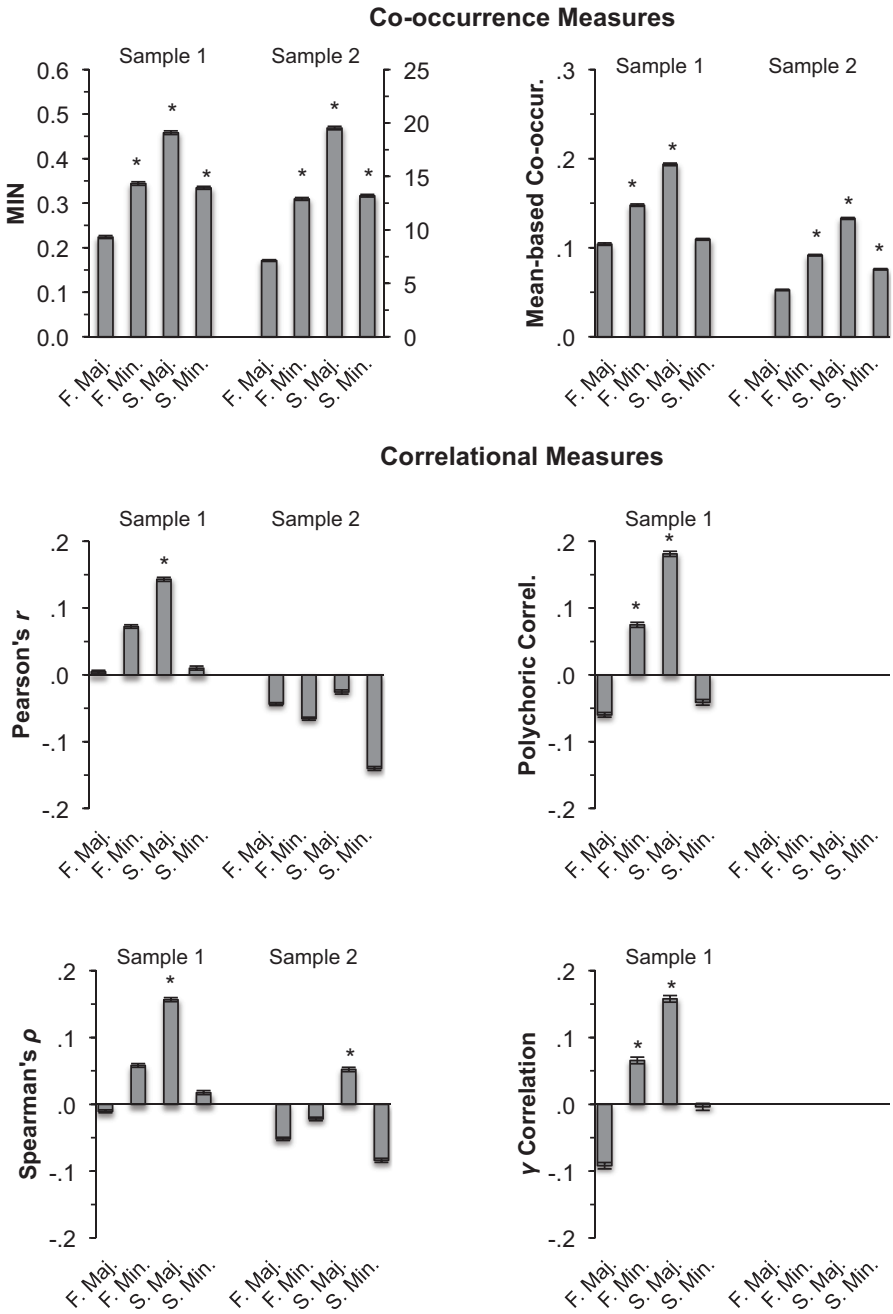

Figure 4. Mean scores on the co-occurrence and correlational measures during fast major, fast minor, slow major, and slow minor songs. Asterisks represent values that differ significantly from the bittersweet scenes at $p = .05/3 = .017$. Polychoric and γ correlations from Sample 2 are not presented because they could not be computed for > 50% of participants.

Canadians show stronger negative correlations when they have been speaking European languages (Perunovic, Heller, & Rafaeli, 2007). Such cultural differences in correlational measures, which may largely be limited to predominantly pleasant situations (Leu et al., 2010), have been widely interpreted as evidence that Westerners experience less mixed emotions than Asians do (e.g., Goetz, Spencer-Rodgers, & Peng, 2008; Larsen & McGraw, 2011; Leu et al., 2010; Leu, Wang, & Koo, 2011; Shiota et al., 2010).

Nonetheless, co-occurrence scores have revealed little evidence for cultural differences in mixed emotions in daily life. Asians show higher MIN scores when asked to indicate how they had felt over the course of the last several weeks (Spencer-Rodgers et al.,

Table 7
Correlations (Spearman's ρ) Among Measures of Co-Occurrence and Recollections of Mixed Emotions

Predictor and criterion	Film task		Music task	
	Sample 1	Sample 2	Sample 1	Sample 2
Recalled time spent experiencing mixed emotions				
MIN	.42**	.15	.63**	.20*
Mean-based co-occurrence	.18	.09	.55**	.10
Residualized MIN	.26**	.14	.08	−.06
Recalled average intensity of mixed emotions				
MIN	.18	.14	.39**	.27**
Mean-based co-occurrence	.05	.07	.37**	.21*
Residualized MIN	.03	.04	.06	.14

Note. MIN = the smaller of a given observation's happiness and sadness ratings.
* $p < .05$. ** $p < .01$.

2010), but it is difficult to make inferences about mixed emotions from such findings because people can experience a great deal of positive and negative emotions over the course of 2 weeks without ever having experienced mixed emotions (Russell & Carroll, 1999; Scollon et al., 2005). In an experience sampling study in which participants did rate how they felt at particular moments (Scollon et al., 2005), Asian American and Japanese participants reported mixed emotions just as infrequently as European Americans did.

Co-occurrence scores also yield little evidence for cultural differences in mixed emotions emerge during specific situations. Asians do report feeling less conflicted about bittersweet advertisements than Westerners do, but they do not report more mixed emotions in response to those advertisements (Williams & Aaker, 2002). Meaningful life transitions represent a potent source of mixed emotions in both Asian (Zhang & Fung, 2009) and Western cultures (Ersner-Hershfield et al., 2008) and Miyamoto, Uchida, and Ellsworth (2010) found no evidence that they elicit more mixed emotions in Japan than in the United States. Japanese participants also reported no more mixed emotions in response to some past failure; they only reported more mixed emotions when asked to describe how they felt about some past success. Taken together, studies involving co-occurrence scores indicate that cultural differences in mixed emotions only emerge in a narrow range of situations.

Conclusion

The *relationship* between two variables is often treated as being synonymous with the *correlation* between them. Nonetheless, the correlation between positive and negative affect is only one aspect of their relationship and our results indicate that the correlation between positive and negative affect tells us little about their co-occurrence. Fortunately, our findings also confirm that co-occurrence can be measured readily. Indeed, any dataset that can yield correlational measures can also yield co-occurrence measures. We hope that our findings about strategies for measuring mixed emotions will contribute to as rich an understanding of the co-occurrence of positive and negative affect as we have of the correlation between them.

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