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Arousal and the Relationship Between Positive and Negative Affect: An Analysis of the Data of Ito, Cacioppo, and Lang (1998)[1]

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Research on positive and negative emotional states has supported several models of how those states relate to each other. Many studies suggest that they are independent, the "bivariate" view, while others suggest that they are inversely correlated, the "bipolar" view. Other research has shown that stress is a major moderator of the relationship; the affects become coupled under conditions of high stress, a contextual model, but are relatively independent otherwise. To expand the range of tests of this dynamic model of affect, we reanalyzed a data set initially reported by Ito, Cacioppo, and Lang (1998) on affect-eliciting picture stimuli. In that study, arousal was assessed separately from positive and negative affect, allowing investigation of a source of interaffect relationships different from stress, per se. Arousal interacted with positive and negative affect, showing both bivariate and bipolar relationships, and effects similar to stress. Affective reactions to the stimuli became more inversely correlated when the affects were high and interacting with higher arousal. The data supported the dynamic model of affect and suggest the need for further analyses of the linkages between stress, arousal, and reduced levels of emotional complexity.

KEY WORDS: affect; arousal; stress.

Research on emotional states involves many different variables and processes. One large area of research has focused on how positive and negative affective feelings relate to each other. A good deal of data support a model that they are independent (a "bivariate" model), while other data suggest that they are inversely correlated

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(a “bipolar” model). Complex methodological issues of measurement underlie both models. Beyond methodology, however, the topic is also an important issue for practice and application of psychological research to the enhancement of human well-being. As things stand now, a practitioner in an applied setting is not clearly informed how to improve well-being: Focus on reducing negative emotions and affects, assuming that the positive affects will ipso facto improve, concentrate on improving the positive aspects of living assuming that the negative will, again ipso facto improve, or intervene on both simultaneously. Obviously much more needs to be known before these important questions can be answered.

Recent studies on the independence of affects are starting to at least approach resolution of some of the major differences. Diener (1999), Feldman Barrett, and Russell (1999); Russell and Feldman Barrett (1999); Watson, Wiese, Vaidya, and Tellegen (1999); Cacioppo, Gardner, & Berntson (1999); and Green, Salovey, and Truax (1999) have concluded that technical issues such as choice of factor rotation procedures, control of correlated and uncorrelated error, and assessmental versus experimental techniques are likely sources of differences in the various models of affect relationships.

An integrative model proposed by the author and colleagues suggests that both models are valid, depending on the contextual state of the person (Potter, Zautra, & Reich, 2000; Reich, Zautra, & Potter, 2001; Zautra, Potter, & Reich, 1997; Zautra, Reich, Davis, Nicolson & Potter, 2000). The central contextual feature is posited to be the degree of stress the person is undergoing. When stress is low, information processing capacity is maximal, with the person able to draw fine distinctions and able to process many dimensions of judgment simultaneously, with a resultant ability to report on both positive and negative affect relatively independently. However, we postulate that a dynamic process is involved here, and independence is not a stable state. High stress acts to reduce a person’s ability to process information, creates simplified, low complexity judgments and poor discrimination. The consequence of stress is, therefore, a cognitive simplification and a failure to respond separately to each affect system, with a simplified, inverse correlation in the affects. This is a dynamic model of affect (DMA).

This contextual model suggests rather specifically the conditions under which stimulus context conditions will lead to a state of independent or inversely correlated affect. It incorporates the state of cognitive simplicity or complexity extant in the person and that state is in turn related to the presence of stress, which reduces system complexity.

Research coming from different traditions appears to be directly applicable to the stress processes we have shown to be related to interaffect relationships. This research involves concepts other than stress, per se, our original focus. The early work of Easterbrook (1959) presented a model and supporting data suggesting that arousal reduces information processing complexity. More recent work by Mano (1994) and Lewinsohn and Mano (1993) on decision-making shows that arousal reduces both information-processing time as well as attentional capacity. Linville (1985; 1987) has shown that information processing complexity (Attneave, 1959) decreases under conditions of stress. These research strands suggest that stress and arousal show similar effects, but while they are at least conceptually related to each other, their distinctive roles in determining the relationship between positive and negative affect have not been studied very thoroughly.

Our prior studies focused on the state of stress as an independent variable relating directly to the correlation between the affects. A model conceptually similar has been proposed by Cacioppo and his colleagues (Cacioppo & Berntson, 1994; Cacioppo, Gardner, & Berntson, 1997; 1999). This model systematically accounts for both bipolar and bivariate outcomes of a given condition. Their model stipulates that either reciprocal activation (bipolarity) or independence (bivariate relations) results when underlying approach and avoidance activation systems are brought into play by any given set of stimulus conditions. They also argue that underlying biological activation systems are basically independent, but conditions requiring an overt response may shift the system to bipolarity or a bivariate outcome. The data of Diener and Emmons (1984) is supportive of both types of approaches; that study reports that the affects are strongly inversely correlated under conditions of high emotionality, and that they will not co-occur at high levels. There are, therefore, several models of how the affects become correlated or function independently.

We have tested our contextual model in various samples of respondents such as college students (Reich et al., 2001; and see Reich & Zautra, 1981) and older adults under the stress of chronic pain (Zautra et al., 1997; Potter, Zautra, & Reich, 2000; Zautra et al., 2000). Also, we have employed a personality trait measure of cognitive simplicity/complexity, Personal Need for Structure (Neuberg & Newsom, 1993) and showed that it also relates to an inverse correlation of positive and negative affect (Reich et al., 2001). In that study, the stress of chronic pain itself was shown to be related to lower levels of cognitive complexity and a consequent inverse correlation of the affects. For a review of all of these studies, see Reich, Zautra, and Davis (in press). Overall, then, our model suggests from several investigations that under low stress or under high cognitive complexity conditions, the affects are relatively uncorrelated, whereas under higher stress and higher levels of cognitive simplicity, they are inversely correlated.

A different methodological approach provides the possibility of new insights into these issues. Ito et al., (1998) have reported on a large-scale investigation of college students' reactions to a set of 472 color slides pretested for the extent to which they elicit positive and negative feelings and the degree of arousal felt from each stimulus ("picture ratings"). The authors presented mean scores for each picture's ratings on positive and negative affect and the degree of arousal they elicited. From these basic data, the investigators also reported the degree of correlation between positive and negative affect for each picture. This score, a correlation coefficient per se, is a valuable datum for testing interaffect relationships in the context of arousal. The data set is particularly valuable in that it contains average affect scores across the stimulus pictures, with correlations across judgments within each picture treated as the unit of analysis. The important data on the interaffect correlations can be retrieved from these data.

In this study, we were able to employ the Ito et al. (1998) data to extend examination of stimulus context factors and the interaffect correlation variable by obtaining a different independent variable measure, in this case arousal, assessed independently from affect and independently from the stress measures such as chronic pain and cognitive simplification we have employed in our prior research. Having independent measures of affect and arousal allows a clearer analysis of the processes that we have shown tend to drive the affects into inverse relationships.

In terms of what we know so far, stress is related to trait cognitive simplification and to the coupling (inverse correlation) of the affects. Stress is related to negative affect, and that raises the question as to whether in research on stress it is the high levels of (negative) affect during stress that leads to the inverse correlation among affects, or is it stress, per se, that couples the affects into an inverse relationship independently of (controlling for) negative affect? As generally conceived, stress involves an organism's reactions to events perceived as threatening the organism's response capabilities. The intent of this study is to go beyond prior measures of stress and cognitive simplification to analyze the role of arousal as employed by other researchers such as Easterbrook (1959) and Ito et al. (1998). The concept of stress suggests system arousal and accompanying negative affect but previous research on the relationships between the affects has not, to date, empirically investigated the roles of negative affect and arousal. An independent measure of arousal that does not ipso facto involve stress and/or negative affect would be useful to answer that question, and the Ito et al. data provide that independent measure. Even more, their independent measure of arousal allows us to test another facet of the relationships involved in these variables. To date, there are no data on the relationships between arousal and positive affect, the other half of the variables involved in emotional complexity. Although stress, negative affect, and arousal all appear on the surface to be related to one another, reactions to positive experiences, which increase positive affect, may also be increasing arousal; this relationship may in and of itself also lead to an increase in inverse interaffect relationships as stress does. We were able to provide an initial assessment of that possibility in the Ito et al. data set.

There is suggestive evidence from other studies that arousal's role may be a significant one in interaffect relationships. Bradley and Lang (1999) for instance, have shown that negative affect's influence on reaction time is differentially magnified when arousal is also heightened. Ashby, Isen, and Turken (1999) point out that arousal and affect are not synonymous and operate independently, so they should be assessed independently of other stimulus reactivity. Employing the data reported by Ito et al. (1998) we were able to test both negative and positive affect's separate relationships and the interacting role of arousal in influencing the degree of interaffect relationships. We expected that arousal, per se, assessed independently of negative affect, would have the same effect of inversely coupling the affects that we have seen in our prior research on stress: Higher levels of arousal should be related to an increased negative/positive interaffect correlation (a bipolar relationship). Also, we expected that negative affect similarly would be related to the interaffect correlation. Very specifically, however, we predicted that the combination of high negative affect and high arousal would lead to the greatest degree of inverse correlation between the affects.

Because of ambiguities in prior research, we did not venture a prediction about the role of positive affect, although the evidence on the relationship between positive affect and information processing has been extensively investigated and is relatively consistent. Isen and colleagues (Isen, 2000; Isen, Daubman, & Nowicki, 1987) and Fredrickson (2001) have shown that the induction of positive affect leads to greater creativity, flexibility, and openness in information processing. It might be expected that such consequences would aid separation of the affects. This has not been demonstrated, nor has the role of arousal and its interaction with positive affect been connected with interaffect correlations. We discuss this issue in more detail in the Discussion section later. Given these uncertainties, in this study we focused on the expected effects of negative affect and sought to obtain basic information on how arousal and positive affect relate to each other and to the interaffect correlation. Given that, we present next our data analytic strategy for utilizing the reported Ito et al. (1998) data and the results of our analyses.

METHOD

Participants

A total of 509 undergraduates (234 males and 275 females) at Ohio State University had participated for course credit. They were run in groups of 12–40 students, each group responding to subsets of 48–55 slides.

Materials

The color slides were taken from the International Affect Picture System of the Center for the Study of Emotion and Attention (CSEA-NIMH; Lang, Greenwald, Bradley, & Hamm, 1993; Lang, Bradley, & Cuthbert, 1995).

Procedure

The participants made a number of ratings of these color slide picture stimuli, but for our purposes in this reanalysis, we are concerned with three of the ratings that they made. (1) Positive evaluative reactions and (2) negative evaluative reactions were rated by check lists of adjectives such as good, bad, etc., but each adjective was to be checked separately and not on a bipolar, single-dimension scale (Cacioppo et al., 1997); (3) arousal was assessed by a pictorial representation with small figures drawn shown a sleepy, calm-looking figure, or a wide-eyed excited figure. The participants' checkings of these figures were transposed to quantitative scale ratings.

For our analyses, then, the basic raw data was composed of a set of 4 scores per stimulus picture: A mean positive affect and negative affect score, a mean arousal score, and a Pearson correlation coefficient computed across positive and negative affect ratings by the participants rating each particular picture. We assume measurement stability of those scores because each raw data value is averaged across 12–40 raters, each rater making ratings across sets of positive and negative adjectives and pictorial arousal ratings, In our analyses, the correlation and regression procedures we performed were averaged across the total set of picture ratings ($N = 460$; see later).

RESULTS

To obtain as accurate estimate of intervariable relationships as possible, we deleted from computation the scores on 12 slides in the Ito et al. (1998) data set that had missing interaffect correlation scores. Therefore, the final sample for our analyses was $N = 460$ pictures' correlation coefficients. Preliminary tests of descriptive statistics showed that all the variables were within normal limits of skewness and kurtosis. The variables were centered by their own means then cross multiplied with arousal following the recommendations of Aiken and West (1991) as procedures for computing multiple regression interaction terms.

To assess basic relationships, Table I presents the means, standard deviations, and zero-order correlations among the variables. The interaffect correlation

Table I. Zero-Order Pearson Correlations Among the Study's Variables

	Positive affect	Negative affect	Arousal	Interaffect correlation
Positive affect	—	$-.85^{***}$	$-.29^{***}$	$-.07$
Negative affect		—	$.56^{***}$	$-.09$
Arousal			—	$-.18^{**}$
M	2.38	2.25	4.88	$-.26$
SD	1.06	1.15	1.33	.24

$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table II. Results of Equations Predicting the Interaffect Correlation Variable From Positive and Negative Affect and Arousal

	B	$SE\ B$	β^a	$F_{(4,455)}$
I Prediction equation				
Positivity (P)	−.11	.02	−.50	28.64***
Negativity (N)	−.13	.02	−.61	30.40***
Arousal (A)	−.01	.01	−.03	.28
Interaction (N × A)	.04	.01	.25	28.15***
II Prediction equation				
Positivity (P)	−.13	.02	−.55	32.46***
Negativity (N)	−.12	.02	−.59	25.96***
Arousal (A)	−.01	.01	−.05	.77
Interaction (P × A)	−.03	.01	−.15	8.89**

Note. For the first prediction equation, $R^2 = .08$ for Step 1; Change in $R^2 = .02$ for Step 2. For the second prediction equation, $R^2 = .08$ for Step 1; Change in $R^2 = .08$ for Step 2.
[a] Values reported from the full prediction equation (Step 2).
** $p < .01$. *** $p < .001$.

variable (rightmost column) showed nonsignificant or very minor correlations with the basic mean affect variables, and a statistically significant but modest relationship with the arousal variable. Both affects were themselves related to arousal, with negative affect showing a strong positive relationship and positive affect a smaller but still significant inverse relationship.

In multiple regression equations, each affect was combined with arousal as a cross-product term to test for interaction effects predicting the interaffect correlation variable. Since the Pearson correlation values in Table I showed significant relationships among all three independent predictor variables, these analyses entered both positive and negative affect and arousal at Step 1 of the prediction equations (main effect tests), followed by the interaction term of either positive affect × arousal or negative affect × arousal at Step 2. This type of analysis in effect controls for the degree of relatedness of the separately measured affects and arousal by partialling their effects out of the test of the interaction term. The results of these analyses are presented in Table II. The data displayed represent the values resulting from the full prediction equation at Step 2 of entry of the predictor variables (the dashed line shows the point of entry of the interaction terms at Step 2).

Both main effect and interaction tests were significant for both negative and positive affect. The interaction patterns of these tests are presented in Figs. 1 and 2, following analytic procedures recommended by Aiken and West (1991). All four regression slopes displayed in Figs. 1 and 2 are significant (all ts > 3.0, all ps < .001). Arousal itself lost its main effect significance in Step 1 when either affect was partialled out of the equation, no doubt because of its significant correlation with the affects as shown in Table I. The interaffect correlation increased in an inverse

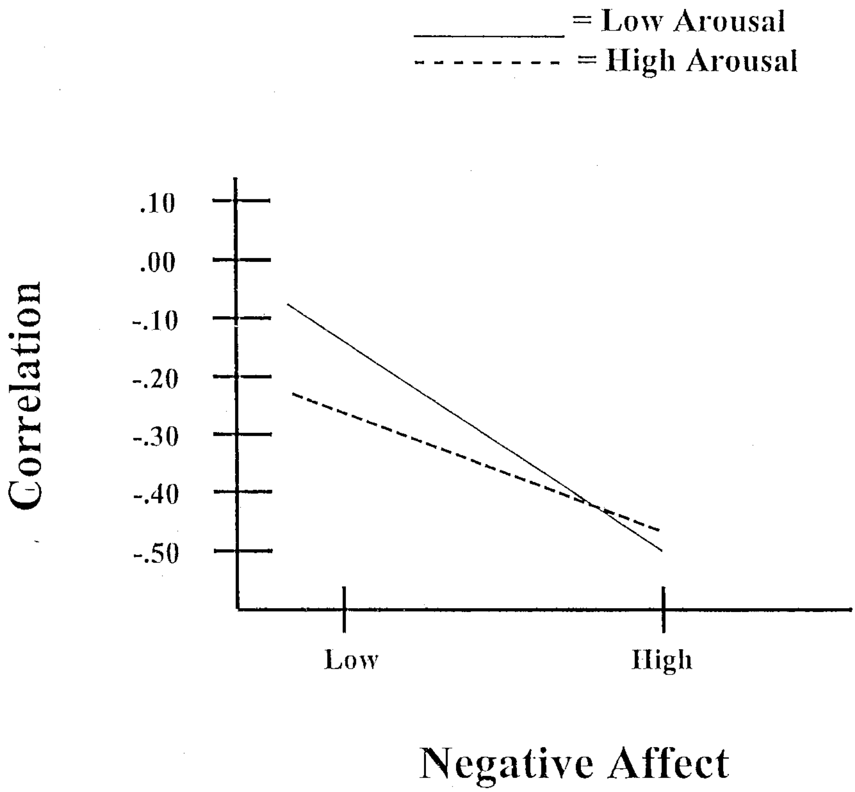

Fig. 1. Graphic plot of the interaction of negative affect and arousal predicting the interaffect correlation variable.

relationship under higher levels of either affect. Arousal significantly altered the slope of those relationships. High levels of negative affect were related to an increased inverse correlation, regardless of arousal. At lower levels of negative affect, only high arousal pictures showed inverse correlations. Positive affect's relationship to the inverse correlation increased at higher levels of positive affect but the effect was more pronounced for higher levels of arousal.

We formed no definite hypotheses for the positive affect variable, with our prior data on stress indicating that negative states (such as chronic pain) were closely linked to a significant interaffect inverse correlation. However, positive affect also is related to that relationship at least when arousal is also entered as an interacting variable. The evidence seems to indicate, then, that higher levels of either affect plus a heightened arousal leads to a significant inverse interaffect relationship.

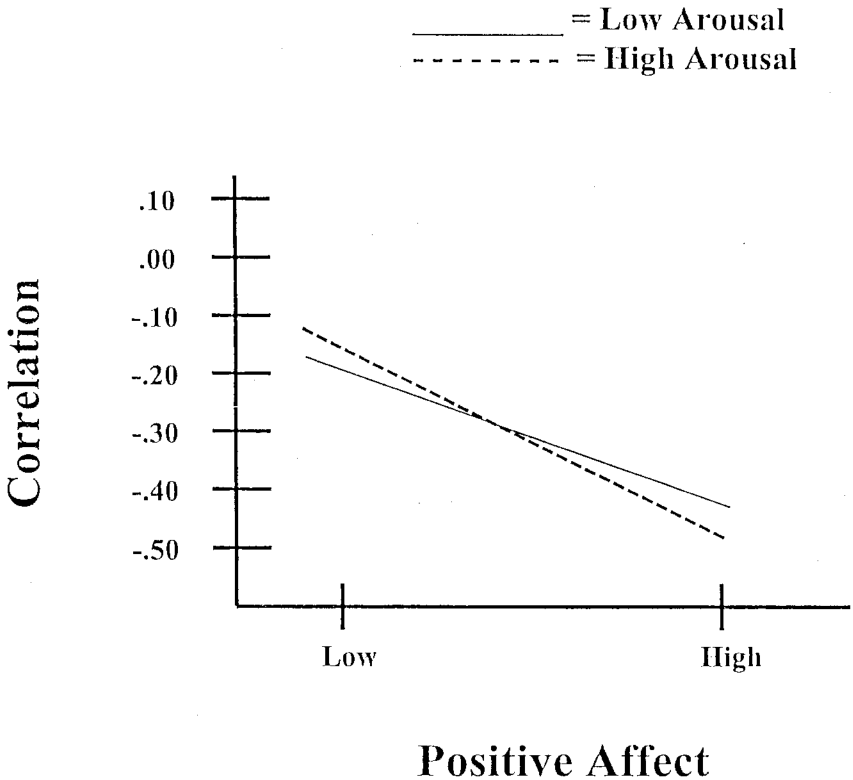

Fig. 2. Graphic plot of the interaction of positive affect and arousal predicting the interaffect correlation variable.

DISCUSSION

Theorists and researchers have linked the concepts of arousal and information processing, arguing that arousal reduces information processing complexity (Easterbrook, 1959; Linville, 1985; 1987; Paulhus & Lim, 1994). Following that line of reasoning, we have also have shown that higher levels of stressful life events and the stress of chronic pain lead to a coupling of the affects into an inverse relationship (Potter et al., 2000; Zautra et al., 1997; Zautra et al., 2000). We interpret this to mean that a reduced complexity in processing affective information about one's life occurs under conditions of high stress. Also, Reich et al. (2001) and Potter et al. (2000) showed that chronic pain is related to trait cognitive simplification and to the predicted inverse relationship between positive and negative affect. We have proposed, then, that the context in which people process information and make judgments about their affect(s) should be an important focus of research and exploration of causal influences. The role of stress as a contextual factor thus would appear to be central.

It was possible to expand on our understanding of the influences on interaffect correlations by employing the data obtained from the assessment methods presented in the Ito et al. (1998) paper.[4] Their methodology provided a direct assessment of arousal, per se, measured separately from positive and negative affect and employing, operationally, an arousal measure different from the variable of stress involved in our other tests of the DMA model. This data set provided a rigorous assessment of affect, arousal, and interaffect correlations, allowing a broader understanding of how the affects relate to each other and to arousal, per se.

Our analyses showed (Table 1) that all three independent variables were significantly correlated with each other. Although Ashby et al. (1999) have shown that arousal and affect are relatively independent processes, the Ito et al. (1998) data we analyzed showed them to interrelate to varying degrees. In turn, to assess interaffect correlations this necessitated controlling for those interrelationships by use of partial regression statistics. This allowed relatively uncontaminated estimates of the relative effects of the main effects and interactions.

Controlling for main effects of both affects and arousal at the first step in stepwise regression equations, arousal's interaction with both positive and negative affect in predicting the interaffect inverse correlation value was significant over and above the main effects. Both affects were related (inversely) to each other as a zero-order correlation. The computation of the basic variables in the original Ito et al. (1998) data set was such that the affects were not directly related to the degree of inverse interaffect correlation value, reducing the likelihood that there was a simple confound of the scoring of the study's variables. Next, in the main regression analyses, with arousal controlled, higher levels of both affects were shown to be related to the magnitude of the interaffect correlation variable. Arousal modified that relationship, with each affect significantly related to the inverse correlation interactively with higher levels of arousal. These analyses partialled out each affect from the other one in any particular test of the relationship. Arousal's own influence appeared only in interaction with either of the affects. This suggests that it is not a "disembodied" influence, but one intimately tied to the affective feelings accompanying reactions in the context set by any particular stimulus picture. It is when arousal magnifies the affective reaction to a stimulus that the reduced information processing predicted by the DMA appears to occur. In this data set, this effect held true for both negative and positive affect.

Negative affect is closer to the DMA processes we described earlier, in that the stress concept employed in prior analyses is conceptually more closely related to negative affect than is positive affect. Positive affect too was related to the

[4]In fact, the optimum test of interaffect relationships would be to compute a correlation coefficient for each person within each picture, then determine the average correlation across pictures for the person. That analysis would be possible for the Ito et al. data set in its original raw state, but those data were not published and were not available for the analyses reported here.

interaffect correlation. It is suggested by these data that the stress concept we have incorporated in our prior studies may in fact have included in it a combination of high negative affect and high arousal. This issue remains to be investigated more thoroughly than possible in the data set reported on here.

Although we have focused much of our attention on the stress-negative affect nexus, these analyses are the first to allow us to examine the role of positive affect in the arousal-stress relationship. Generally stress is thought of as having a strong component of negative affect, in the sense of increased arousal. Positive affect is not ordinarily thought of as stressful, but when operating in conjunction with higher levels of arousal, it too was found to be related to a greater magnitude of interaffect inverse correlation. A more intensive investigation of this possibility is needed. The extent to which positive experiences might act similarly to negative ones was shown by Block and Zautra (1981) who found that increased frequency of experiencing positive daily events was related to greater experienced psychological distress. This may have been due to a suggestive correlation between the frequencies of positive and negative daily event occurrences. The positive stimulus pictures in the Ito et al. (1998) study did relate significantly to arousal, and arousal significantly modified the interaffect relationship, as negative affect did. Therefore, our data suggest that increased positive affect, when combined with increased arousal, also can reduce PA–NA differentiation, especially when combined with increased arousal. The relationships we found here accounted for somewhat less of the variance than negative affect/arousal did, but they were still statistically significant. At this point, then, this study has presented evidence that both positive and negative affect, when at higher levels themselves and in combination with higher levels of arousal (assessed independently), do operate to reduce emotional complexity in terms of an increased interaffect inverse relationship.

Our reanalysis of the data of Ito et al. (1998) was guided by our DMA model that the degree of (inverse) correlation of the affects would be directly affected by the degree of arousal the participants reported. The translation of their concept and measurement of arousal to our concept of stress is on the face of it a reasonable assumption, but one in need of further investigation. In our prior research, we have treated stress as resulting from participants' reports of their recent stressful life events or their pain they were experiencing from their chronic illness (such as osteoarthritis, rheumatoid arthritis, and fibromyalgia). None of these were explicitly operationalized as arousal measures, per se, so the explicit measurement of arousal in the Ito et al. study is a valuable addition to the body of research data on contextual factors in determining the interaffect correlation variable. This is especially so since the data of the reanalysis did in fact support predictions from the DMA model. Even at this point, though, we regard the translation of the Ito et al. concept of arousal as only a rough fit to our concept of stress, and it is only that: A translation with uncertainties in need of more extensive investigation. Simultaneous measurement of perceived stress, arousal, and positive and negative affect would contribute greatly to our understanding of this issue.

One remaining area of ambiguity is our assumption that the Ito et al. (1998) concept of arousal acts to increase cognitive simplification and the simpler structure of the affects. The latter assumption has some empirical support, as we indicated earlier. Linville (1985; 1987) has explicitly confirmed that model, and we have shown (Reich et al., 2001) that people under stress from chronic pain score lower on a measure of cognitive simplification. Nevertheless, further tests of the arousal/simplification assumption are certainly warranted.

It is important both scientifically and practically to study the relationship between the affects. As psychologists attempt to move their science from the laboratory to the field, to the study of significant social problems and to the enhancement of well-being, more research and application of the data of the many studies in this area certainly seems justified and worthwhile.

Our own position is that contextual factors such as stress and arousal and the lack of differentiation of the affects deserves much more attention. Forays into these issues already have been made. Recent research and theory on emotional intelligence (Salovey, Mayer, Goldman, Turvey, & Palfai, 1995; Salovey, Rothman, Detweiler, & Steward, 2000) and mindfulness (Kabat-Zinn, 1982) are suggesting the mental health benefits of inducing people to increase the differentiation among their emotional and controlling their levels of arousal in their emotional responding. Our data suggest that lower levels of either negative or positive affect in conjunction with lower arousal will lead to greater emotional differentiation. In turn, this may well be related to better coping and adjustment and mental health. This issue would appear to be an important target for future research investigation and application in clinical settings.

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