Emotion
2002, Vol. 2, No. 4, 412–417

1528-3542/02/$5.00 DOI: 10.1037//1528-3542.2.4.412

BRIEF REPORT

Experiencing Activation: Energetic Arousal and Tense Arousal Are Not Mixtures of Valence and Activation

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R. E. Thayer (1989) proposed 2 types of activation: energetic arousal (awake–tired) and tense arousal (tense–calm). This view has been challenged by claims that energetic arousal and tense arousal are mixtures of valence and a single activation dimension. The authors present a direct test of this hypothesis by computing the correlation between the residuals of energetic arousal and tense arousal after removing the shared variance with valence. Whereas the valence activation hypothesis predicts a strong positive correlation between the 2 residuals, the authors found that it was not significantly different from 0. This finding reaffirms the view of energetic arousal and tense arousal as 2 distinct types of activation.

In 1967, Thayer conducted a seminal study of the dimensionality of people's experiences of activation. Initially, he obtained four independent factors, two Activation factors and two Deactivation factors. Subsequent research suggested, however, that the independence of the Activation and Deactivation factors were a method artifact. Accordingly, activation was reconceptualized as varying along two dimensions: *energetic arousal* (ranging from feeling sleepy to feeling awake) and *tense arousal* (ranging from feeling calm to feeling nervous; Matthews, Jones, & Chamberlain, 1990; Schimmack & Grob, 2000; Steyer, Schwenkmezger, Notz, & Eid, 1994; Thayer, 1989; Watson, Wiese, Vaidya, & Tellegen, 1999).

This two-dimensional conceptualization of activation is supported by several key findings. First, the two activation dimensions are related to different causes. For example, energetic arousal is influenced by a circadian rhythm (Schimmack, 1999; Thayer, 1989; Watson et al., 1999) that corresponds to activity in brain cells that regulate organisms' sleep–wake cycle (Tucker & Williamson, 1984). Tense arousal does not show a similar circadian rhythm. Second, the two activation dimensions can change in opposite directions. For example, Gold, MacLeod, Deary, and Frier (1995) examined the influence of experimentally induced hypoglycemia on energetic arousal and tense arousal. Whereas energetic arousal decreased in response to low blood sugar levels, tense arousal increased, presumably as the result of an emergency response to mobilize the body to take action to restore blood sugar levels. Third, the two types of activation have different consequences. For example, several studies show that energetic arousal is a better predictor of cognitive tasks than tense arousal (Heller, Nitschke, & Lindsay, 1997; Matthews & Davies, 2001; Matthews & Westerman, 1994).

Notwithstanding these findings, the two-dimensional conceptualization of activation has recently become the topic of renewed controversy (Russell & Barrett, 1999; Schimmack & Grob, 2000; Watson et al., 1999; Yik, Russell, & Barrett, 1999). The present article seeks to resolve this controversy by means of a direct test of the recent challenge to the two-dimensional model of activation.

The Challenge of the Two-Dimensional Model of Activation

Several articles suggested that the two-dimensional model of activation is an artifact because it neglects

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We thank Stephane Coté and Romin Tafarodi for helpful comments.

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valence (e.g., Yik et al., 1999). According to this alternative view of activation, markers of energetic arousal (awake–tired) and tense arousal (tense–calm) represent mixtures of a single type of activation and valence. Feeling awake describes a state of high activation and positive valence, whereas feeling tired describes a state of low activation and negative valence. Feeling tense describes a state of high activation and negative valence, whereas feeling calm describes a feeling of deactivation and positive valence. Furthermore, the discriminant validity of energetic arousal and tense arousal is attributed to the fact that the two dimensions incorporate valence in opposite directions. Energetic arousal increases with valence, whereas tense arousal decreases with valence.

If energetic arousal were a perfect combination of activation and positive valence, and tense arousal were a perfect combination of activation and negative valence, then the correlation between the two arousal dimensions would be zero (Yik et al., 1999). In short, the weak correlation between energetic arousal and tense arousal may provide misleading evidence about the dimensionality of activation because energetic arousal and tense arousal may combine a single type of activation with valence. Subsequently, we refer to this proposal as *the valence activation hypothesis*.

A Direct Test of the Valence Activation Hypothesis

We conducted a straightforward test of the nature of energetic arousal and tense arousal. To conduct this test, it was only necessary to measure energetic arousal, tense arousal, and valence. Provided that variance due to valence is measured with a reliable and valid scale, it is possible to remove the valence component of energetic arousal and tense arousal. For example, energetic arousal can be regressed onto valence, and the residual variance in energetic arousal can be retained. This residual represents the variance in energetic arousal that remains after valence has been removed. According to the valence activation hypothesis, energetic arousal has two components, valence and activation. Therefore, after removing variance due to valence, the residual of energetic arousal represents variance in activation. Similarly, the valence activation hypothesis regards tense arousal as a mixture of valence and activation. Hence, after removing the variance in valence from tense arousal, the residual of tense arousal should also represent variance in activation.

In sum, the valence activation hypothesis predicts that once the valence component has been removed from energetic arousal and from tense arousal, both residual variables reflect variance along the same activation dimension. Therefore, the two residual variables should be highly correlated (as they are just different measures of a single activation dimension). In contrast, the two-dimensional view of activation assumes that energetic arousal and tense arousal are distinct types of activation. Therefore, the residual variances in each dimension should still reflect variation along different dimensions even after their shared variance with valence has been removed. As a consequence, the residuals of energetic arousal and tense arousal should still support the discriminant validity of the two activation dimensions even after the shared variance with valance has been removed.

To conclude, the valence activation hypothesis and the two-dimensional view of activation make distinct predictions about the relation between energetic arousal and tense arousal once shared variance with valence has been statistically removed. The valence activation hypothesis predicts a high positive correlation because both measures are supposed to share the same kind of activation. In contrast, the two-dimensional model of activation predicts a weak correlation because both dimensions are supposed to reflect two different types of activation.

Although ideally the valence activation hypothesis predicts a correlation of 1, this prediction is not realistic for several reasons. First, measures can be contaminated by measurement error, which can attenuate the relation between variables. To address these concerns, we controlled for influences of random and systematic measurement error. Tense arousal and energetic arousal may also contain unique valid variance that is not shared with valence and activation. Nevertheless, a shared-activation dimension should produce positive correlations between the residuals of tense arousal and energetic arousal.

What About Measurement Error?

Proponents of the valence activation hypothesis have emphasized that measurement error can distort empirical results, and they have typically attributed findings at odds with their model to measurement error (Yik et al., 1999). As it turns out, however, measurement error is not a serious obstacle to our test of the valence activation hypothesis. In discussing this issue, it is important to distinguish between random and systematic error. Random measurement error can be controlled simply by examining the relation between constructs at the level of latent factors. Systematic measurement error (caused by response styles) also does not threaten the validity of our analyses for several reasons. First, although there is some concern about the influence of response styles on checklists (Green, Goldman, & Salovey, 1993), studies with rating scales often find nonsignificant or small effects of systematic measurement error (Green et al., 1993; Schimmack, Boeckenholt, & Reisenzein, 2002; Watson & Clark, 1997). Second, systematic error can be removed by first assessing energetic arousal and tense arousal with unipolar scales and then subtracting one pole from the other pole. This approach is common practice in the assessment of tense arousal and energetic arousal (Matthews et al., 1990; Schimmack & Grob, 2000; Steyer et al., 1994; Thayer, 1989). Finally, our reliance on residuals of energetic arousal and tense arousal also reduces the problem of systematic measurement error. The reason is that systematic measurement error is shared between the activation ratings and the valence ratings. Hence, it becomes part of the shared variance between activation and valence and not part of the activation residuals (i.e., the variance in activation that is not shared with the valence measure).

What Is New?

Several studies have examined and reported the zero-order correlations between energetic arousal and tense arousal (Matthews et al., 1990; Schimmack & Grob, 2000; Steyer et al., 1994). However, simple correlations are unable to discriminate clearly between the competing models of activation. The reason is that both models are consistent with the same pattern of zero-order correlations. Both models predict a positive correlation between valence and energetic arousal, a negative correlation between valence and tense arousal, and independence between energetic arousal and tense arousal. In contrast, the correlations between the residuals of energetic arousal and tense arousal after removing shared variance with valence leads to competing predictions. The valence activation model predicts a strong positive correlation, whereas the two-dimensional model predicts a correlation close to zero.

It is true that the pattern of simple correlations determines the correlation of the residuals. However, researchers have not reported the correlation between the residuals, and the ongoing controversy attests to the fact that they have no real sense of the magnitude of this correlation. We provide an estimate of this crucial correlation in an analysis of data from a large, diverse sample.

Disclaimer

Before we present the test and the results, it is important to note that this article does not present a complete alternative structural theory of emotions. It also does not resolve the debate over discrete emotions versus dimensional models of affect. We also do not address the debate about unipolar versus bipolar models of affect. Finally, we do not provide a review of the existing neurophysiological research on activation and arousal. Rather, this article focuses exclusively on one point of contention in contemporary affect research: Are energetic arousal and tense arousal really two distinct types of activation? Or are energetic arousal and tense arousal mixtures of activation and valence?

Method

Participants

Data were collected at the University of Illinois, Urbana–Champaign (131 students), the University of Texas, El Paso ($n = 59$), the University of the Virgin Islands ($n = 60$), and the University of Toronto at Mississauga ($n = 460$).

Materials and Procedure

Energetic arousal, tense arousal, and valence were assessed with Schimmack and Grob's (2000) 18-item questionnaire. The questionnaire consists of three items for each pole of the three dimensions (valence: pleasant, good, positive vs. unpleasant, bad, negative; energetic arousal: awake, alert, wakeful vs. sleepy, tired, drowsy; tense arousal: restless, tense, jittery vs. at rest, relaxed, calm). The response format was a unipolar intensity scale (0 = *not at all,* 1 = *slightly,* 2 = *moderately,* 3 = *strongly*). To obtain bipolar indicators of each dimension, ratings on the lower pole items were subtracted from ratings on the higher pole items. Besides using bipolar indicators to reduce response style effects, we had two other reasons for using bipolar indicators. First, Yik et al. (1999) also used bipolar indicators, although they used quasi-bipolar response formats (cf. Russell & Carroll, 1999), whereas we created bipolar indicators from unipolar ratings. Second, unipolar indicators present a methodological challenge for structural analyses of affect (Russell & Carroll, 1999; Schimmack, 2001). The reliance on bipolar indicators is not a problem for the present research question because both the valence activation model and the two-dimensional model of activation assume approximate bipolarity of energetic arousal, tense arousal, and valence (Matthews et al., 1990; Russell & Barrett, 1999; Russell & Carroll, 1999; Steyer et al., 1994; Yik et al., 1999).

Results

We used structural equation modeling to eliminate variance caused by random error. We first tested a measurement model in which each latent factor was based on its three indicators, and the latent factors were free to correlate with each other (cf. Schimmack & Grob, 2000, for details). The model fit was acceptable (evaluation criteria: comparative fit index [CFI] > .90, root-mean-square error of approximation [RMSEA] < .08), χ^2 (24, N = 710) = 85, CFI = .983, RMSEA = .060. The measurement model reveals the correlations between the three latent factors without random measurement error. Energetic arousal was positively correlated with valence (r = .46), tense arousal was negatively correlated with valence (r = −.65), and energetic arousal and tense arousal were weakly negatively correlated (r = −.28). These zero-order correlations are consistent with previous findings (Matthews et al., 1990; Schimmack & Grob, 2000; Steyer et al., 1994).

The second model imposed causal paths from the valence factor to the arousal factors. These causal paths represent the assumption of the valence activation hypothesis that valence partly determines energetic arousal and tense arousal, and it simultaneously allows estimating the correlation between the residuals of energetic arousal and tense arousal. The magnitude of this parameter is the crucial test of the two models of activation. If the two residuals are highly positively correlated, energetic arousal and tense arousal share a common source of variance other than valence. If the correlation between the two residuals is weak, energetic arousal and tense arousal contain distinct sources of variance. This goodness-of-fit test for this second model is the same as for the first model because it contains the same number of parameters. In this model, the estimated correlation between the residuals of energetic arousal and tense arousal was close to zero and not statistically significant, despite the large sample size (see Figure 1). It should be noted that the model in Figure 1 is designed to test the valence activation hypothesis. The causal path from valence to the activation factors is imposed for this purpose, and the model does not reveal the causal processes underlying the correlations between valence and the two activation dimensions.

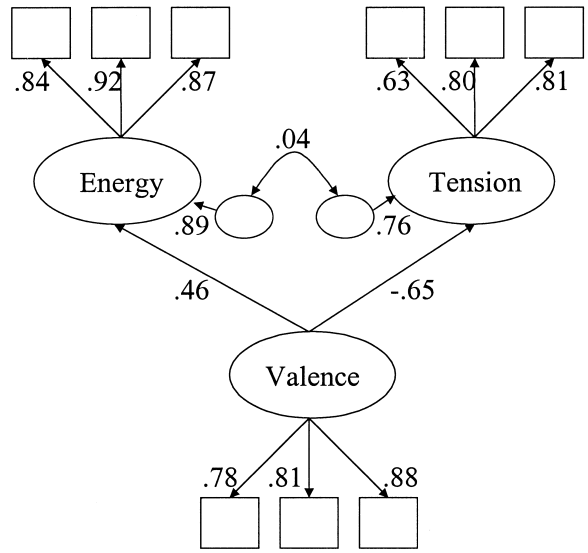

Figure 1. Relation between valence, energetic arousal, tense arousal, and residuals of energetic arousal and tense arousal without shared variance in valence.

Discussion

This study presented a new approach to resolving the recent controversy about the conceptualization of activation. Previous researchers regarded energetic arousal and tense arousal as two separate dimensions of activation that are influenced by different causal factors and seem to be based on different neurological systems. In contrast, the valence activation hypothesis assumes that energetic arousal and tense arousal are mixtures of a single activation dimension with valence. As explained previously, the correlation between the residuals of energetic arousal and tense arousal, after the shared variance with valence has been removed, provides a direct test of this hypothesis. According to the valence activation hypothesis, a strong positive correlation should emerge, whereas the two-dimensional model of activation predicts a correlation close to zero. These predictions can also be formulated in terms of convergent and discriminant validity: The valence activation hypothesis predicts that after removing valence, energetic arousal and tense arousal should show high convergent and low discriminant validity, because both residuals reflect the same activation dimension. In contrast, the two-dimensional model of activation assumes that the residuals should show high discriminant validity and low convergent validity because they represent two distinct types of activation. A test of this prediction provided unambiguous support for the two-dimensional model of activation.

This finding cannot be attributed to measurement artifacts. Random error was controlled by means of estimating the residual correlations between latent factors. Systematic measurement error caused by response styles also cannot explain the results for reasons discussed in detail in the introduction. However, it is also noteworthy that response styles would inflate correlations, which would benefit the valence activation model and not the two-dimensional model of activation that was actually supported. Hence, response styles cannot explain our findings.

Another concern may be that the residuals no longer contain any reliable variance after the shared variance with valence has been removed. In this case, the lack of a correlation between residuals would indicate that valence accounts for most of the variance in the activation measures. However, Figure 1 shows that the residuals explain more than 50% of the variance in the Activation factors. If the residuals can correlate that highly with a factor, then they could correlate as highly with each other. Hence, the zero correlation between the two residuals cannot be attributed to a lack of reliable variance in the residuals.

It is also not possible to attribute the results to a chance finding, because the analyses were based on a large data set comprising four divergent samples. In addition, the observed simple correlations are consistent with previous findings in the literature (Matthews et al., 1990; Steyer et al., 1994). As noted earlier, the pattern of simple correlations determines the correlation between the residuals of energetic arousal and tense arousal after controlling for valence. Hence, we were able to examine the generalizability of the present findings by computing the crucial correlation between the residuals of energetic arousal and tense arousal from the published simple correlations. The results confirmed the present findings (.14 from Matthews et al., 1990; −.03 from Steyer et al., 1994). The high consistency across studies is not surprising because Reisenzein and Schimmack (1999) demonstrated that the raw correlations between affect ratings are highly replicable across studies.

Finally, there may be some concern that our analyses were biased toward the two-dimensional model. After all, it seems more difficult to achieve a correlation of 1 than a correlation of 0, even after carefully controlling measurement error. One reason for attenuated correlations could be valid variance in affects that is not explained by valence and activation (Russell & Barrett, 1999). A more moderate valence activation hypothesis could allow for some specific variance in energetic arousal and tense arousal. Viewed this way, the correlation between the residuals of energetic arousal and tense arousal is a quantitative index of the importance of a general activation dimension. The stronger the correlation between the residuals, the more it makes sense to postulate a common activation dimension. However, given that the correlation is close to zero, support for a moderate valence activation model is also weak.

Are Tense Arousal and Energetic Arousal Basic Dimensions?

The notion of (psychologically) basic dimensions of affect comprises two claims. First, a basic dimension is not a mixture or combination of other dimensions. Second, other affects are reducible to the basic dimensions. It is important to distinguish between these two claims (see Reisenzein, 2000). For example, discrete emotion theories consider some emotions as basic in the sense that they are not reducible, but not necessarily in the sense that other emotions can be reduced to the basic emotions (see, e.g., Ekman, 1992). In the same vein, we consider energetic arousal and tense arousal as basic dimensions of activation. They cannot be reduced to more basic dimensions such as valence or activation. However, we do not consider energetic arousal and tense arousal to be basic elements of other emotions. In particular, we do not propose that the valence of affective experiences can be reduced to activation patterns. Hence, we do not equate pleasure with a state of calm wakefulness or displeasure with a state of tense tiredness (see also Matthews et al., 1990; Steyer et al., 1994). In short, although we propose that energetic arousal and tense arousal cannot be reduced to valence and activation, we do not claim that valence can be reduced to energetic arousal and tense arousal (cf. Schimmack & Grob, 2000).

This position is difficult to understand only if the structure of affect were truly two-dimensional. If this were the case, then the claim that energetic arousal and tense arousal are basic dimensions would imply that other dimensions are mere mixtures of these dimensions. However, quantitative tests show that two-dimensional models show a poor fit to actual data (cf. Schimmack & Grob, 2000; Watson et al., 1999). We suggest that future research on affect structure should move toward more precise tests of structural hypotheses. The present article demonstrates that such tests can provide clear and unambiguous evidence about controversial issues.

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Received March 4, 2002
Revision received May 27, 2002
Accepted July 3, 2002 ■