AMERICAN PSYCHOLOGICAL ASSOCIATION

Emotion

ISSN: 1528-3542

2023, Vol. 23, No. 2, 332–344
https://doi.org/10.1037/emo0001095

On the Relationship Between Valence and Arousal in Samples Across the Globe

Michelle Yik[1], Chiel Mues[2], Irene N. L. Sze[1], Peter Kuppens[2], Francis Tuerlinckx[2], Kim De Roover[3], Felity H. C. Kwok[1], Shalom H. Schwartz[4], Maher Abu-Hilal[5], Damilola Fisayo Adebayo[6], Pilar Aguilar[7], Muna Al-Bahrani[5], Marc H. Anderson[8], Laura Andrade[9], Denis Bratko[10], Ekaterina Bushina[11], Jeong Won Choi[12], Jan Cieciuch[13, 14], Vincent Dru[15], Uwana Evers[16], Ronald Fischer[17], Ivonne Andrea Florez[18], Ragna B. Garðarsdóttir[19], Aikaterini Gari[20], Sylvie Graf[21, 22], Peter Halama[23], Jamin Halberstadt[24], Magdalena S. Halim[25], Renata M. Heilman[26], Martina Hřebíčková[22], Johannes Alfons Karl[17], Goran Knežević[27], Michal Kohút[28], Martin Kolnes[29], Ljiljana B. Lazarević[27], Nadezhda Lebedeva[11], Julie Lee[16], Young-Ho Lee[12], Chunquan Liu[30], Rasmus Mannerström[31], Iris Marušić[32], Florence Nansubuga[33], Oluyinka Ojedokun[6], Joonha Park[34], Tracey Platt[35], René T. Proyer[36], Anu Realo[29, 37], Jean-Pierre Rolland[15], Willibald Ruch[38], Desiree Ruiz[7], Florencia M. Sortheix[39], Alexander Georg Stahlmann[38], Ana Stojanov[24], Włodzimierz Strus[13], Maya Tamir[4], Cláudio Torres[9], Angela Trujillo[40], Thi Khanh Ha Truong[41], Akira Utsugi[42], Michele Vecchione[43], Lei Wang[30], and James A. Russell[44]

This article was published Online First April 21, 2022.

Michelle Yik https://orcid.org/0000-0003-0104-3662
Chiel Mues https://orcid.org/0000-0001-6579-0128
Irene N. L. Sze https://orcid.org/0000-0001-6702-9180
Peter Kuppens https://orcid.org/0000-0002-2363-2356
Francis Tuerlinckx https://orcid.org/0000-0002-1775-7654
Kim De Roover https://orcid.org/0000-0002-0299-0648
Felity H. C. Kwok https://orcid.org/0000-0003-2179-720X
Shalom H. Schwartz https://orcid.org/0000-0003-2673-9332
Maher Abu-Hilal https://orcid.org/0000-0002-7026-498X
Damilola Fisayo Adebayo https://orcid.org/0000-0002-5326-948X
Muna Al-Bahrani https://orcid.org/0000-0002-0124-845X
Marc H. Anderson https://orcid.org/0000-0001-7379-0902
Laura Andrade https://orcid.org/0000-0002-1876-3650
Denis Bratko https://orcid.org/0000-0002-2482-4413
Ekaterina Bushina https://orcid.org/0000-0001-9560-9609
Jeong Won Choi https://orcid.org/0000-0002-7227-7602
Uwana Evers https://orcid.org/0000-0002-1435-7655
Ronald Fischer https://orcid.org/0000-0002-3055-3955
Sylvie Graf https://orcid.org/0000-0002-7810-5457
Peter Halama https://orcid.org/0000-0002-6938-4845
Magdalena S. Halim https://orcid.org/0000-0003-2158-7587
Renata M. Heilman https://orcid.org/0000-0003-1405-3210
Johannes Alfons Karl https://orcid.org/0000-0001-5166-0728
Martin Kolnes https://orcid.org/0000-0003-3953-8724
Nadezhda Lebedeva https://orcid.org/0000-0002-2046-4529
Julie Lee https://orcid.org/0000-0001-8718-388X
Young-Ho Lee https://orcid.org/0000-0003-4970-0836
Florence Nansubuga https://orcid.org/0000-0001-6569-8700
Oluyinka Ojedokun https://orcid.org/0000-0002-3497-4618
Joonha Park https://orcid.org/0000-0002-0764-5173
Tracey Platt https://orcid.org/0000-0001-6628-7057
René T. Proyer https://orcid.org/0000-0001-7426-4939
Anu Realo https://orcid.org/0000-0003-0649-274X
Jean-Pierre Rolland https://orcid.org/0000-0002-7612-0995
Willibald Ruch https://orcid.org/0000-0001-5368-3616
Desiree Ruiz https://orcid.org/0000-0002-8134-8142
Alexander Georg Stahlmann https://orcid.org/0000-0003-3694-7610
Ana Stojanov https://orcid.org/0000-0002-8377-4372
Włodzimierz Strus https://orcid.org/0000-0002-5044-5660
Maya Tamir https://orcid.org/0000-0002-2675-8042
Cláudio Torres https://orcid.org/0000-0002-3727-7391
Angela Trujillo https://orcid.org/0000-0002-7393-4563
Thi Khanh Ha Truong https://orcid.org/0000-0003-3940-8399
Akira Utsugi https://orcid.org/0000-0002-6801-2804
James A. Russell https://orcid.org/0000-0003-1041-3717
Co-author Maher Abu-Hilal is deceased.

Preparation of the article was facilitated by the Hong Kong Research Grants Council's General Research Fund (Projects 16651916 and 16601818) awarded to Michelle Yik. The contributions of Sylvie Graf and Martina Hřebíčková were supported by the Czech Science Foundation (20-01214S) and the Institute of Psychology, Czech Academy of Sciences (RVO: 68081740). The contributions of Nadezhda Lebedeva and Ekaterina Bushina were supported by the Basic Research Program at HSE University, RF. The contributions of Francis Tuerlinckx and Peter Kuppens were supported by KU Leuven Research Council Grant C14/19/054. The contributions of Anu Realo and Martin Kolnes were supported by institutional research funding (IUT2–13) from the Estonian Ministry of Education and Sciences. These findings were presented as a poster at the 2021 Society for Affective Science Annual Conference. We have no conflicts of interest to disclose.

Correspondence concerning this article should be addressed to Michelle Yik, Division of Social Science, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong. Email: michelle.yik@ust.hk

[1] Division of Social Science, Hong Kong University of Science and Technology
[2] Faculty of Psychology and Educational Sciences, KU Leuven-University of Leuven
[3] Department of Methodology and Statistics, Tilburg University
[4] Department of Psychology, The Hebrew University of Jerusalem
[5] College of Education, Sultan Qaboos University
[6] Department of Psychology, Adekunle Ajasin University
[7] Department of Psychology, Universidad Loyola Andalucia
[8] Department of Management and Entrepreneurship, Iowa State University
[9] Department of Basic Psychological Processes, University of Brasilia
[10] Department of Psychology, Faculty of Social Sciences and Humanities, University of Zagreb
[11] Centre for Socio-Cultural Research, National Research University Higher School of Economics
[12] Department of Psychology, The Catholic University of Korea
[13] Institute of Psychology, Cardinal Stefan Wyszyński University in Warsaw
[14] University Research Priority Program "Social Networks", University of Zurich
[15] Laboratoire Interactions Cognition Action Émotion (LICAÉ), University Paris Nanterre
[16] Department of Marketing, University of Western Australia
[17] School of Psychology, Victoria University of Wellington
[18] Department of Behavioral Health, Kaiser Permanente, Atlanta, Georgia, United States
[19] Faculty of Psychology, University of Iceland
[20] Department of Psychology, National and Kapodistrian University of Athens
[21] Institute of Psychology, University of Bern
[22] Institute of Psychology, Czech Academy of Sciences
[23] Centre of Social and Psychological Sciences, Slovak Academy of Sciences
[24] Department of Psychology, University of Otago
[25] Graduate Program of Professional Psychology, ATMA JAYA Catholic University of Indonesia
[26] Department of Psychology, Babeș-Bolyai University
[27] Department of Psychology, University of Belgrade
[28] Department of Psychology, University of Trnava
[29] Institute of Psychology, University of Tartu
[30] School of Psychological and Cognitive Sciences, Peking University
[31] Department of Education, University of Helsinki
[32] Centre for Educational Research and Development, Institute for Social Research in Zagreb
[33] School of Psychology, Makerere University
[34] School of Management, NUCB Business School
[35] Faculty of Health Sciences and Wellbeing, University of Sunderland
[36] Department of Psychology, Martin-Luther-University Halle-Wittenberg
[37] Department of Psychology, University of Warwick
[38] Department of Psychology, University of Zurich
[39] Swedish School of Social Sciences, University of Helsinki
[40] Faculty of Psychology, Universidad de La Sabana
[41] University of Social Sciences and Humanities, Vietnam National University
[42] Graduate School of Humanities, Nagoya University
[43] Department of Social and Developmental Psychology, Sapienza University of Rome
[44] Department of Psychology and Neuroscience, Boston College

Affect is involved in many psychological phenomena, but a descriptive structure, long sought, has been elusive. Valence and arousal are fundamental, and a key question–the focus of the present study–is the relationship between them. Valence is sometimes thought to be independent of arousal, but, in some studies (representing too few societies in the world) arousal was found to vary with valence. One common finding is that arousal is lowest at neutral valence and increases with both positive and negative valence: a symmetric V-shaped relationship. In the study reported here of self-reported affect during a remembered moment (N = 8,590), we tested the valence-arousal relationship in 33 societies with 25 different languages. The two most common hypotheses in the literature–independence and a symmetric V-shaped relationship–were not supported. With data of all samples pooled, arousal increased with positive but not negative valence. Valence accounted for between 5% (Finland) and 43% (China Beijing) of the variance in arousal. Although there is evidence for a structural relationship between the two, there is also a large amount of variability in this relation.

Keywords: valence, arousal, subjective experience, structure of affect, culture

Supplemental materials: https://doi.org/10.1037/emo0001095.supp

A person is "never in a state entirely free from feeling."

(Wundt, 1897/1998, p. 92)

Affective feelings infuse mental processes and behaviors related to health, well-being, psychopathology, and decision making. Yet, psychology has not achieved an agreed upon descriptive structure of affect. Valence and arousal have often been identified as fundamental properties of affect, but the relationship between the two has not been agreed upon or examined across the globe. The present study focuses on momentary affect. We asked, in 33 different samples, two basic questions: How are valence and arousal related to each other in subjective experience? Does this relationship vary across societies? The study examined these questions by asking participants to report their feelings in "a clearest moment" during the previous day.

Valence and Arousal

Valence (also known as pleasure-displeasure or hedonic tone) is an elementary dimension of conscious affective feeling (Reisenzein, 1992; Wundt, 1897/1998) and the most commonly found fundamental property of affect (Larsen & Diener, 1992; Yik et al., 1999, 2002, 2011) – indeed, sometimes the only factor found in self-reports of affect (Williams et al., 1989). Still, controversy remains as to whether valence is one bipolar dimension or two separate dimensions (for progress on this issue, see Larsen et al., 2001; Russell, 2017; Russell & Carroll, 1999; Yik, 2007). Arousal (also known as activation, energy, or tension) often emerges as a second factor in self-reported affect (Yik et al., 2002) and was prominent in earlier psychological writings (e.g., Berlyne, 1960; Cannon, 1927; Schachter & Singer, 1962). Self-reported arousal is related to a range of factors from food to personality to neurochemistry (Thayer, 1989).

Theoretical Relations Between Valence and Arousal

How valence and arousal are related to each other has received less attention, but is essential, nonetheless. There are hints that arousal increases with intensity of both positive and negative valence in certain conditions. For instance, arousal is a V-shaped function of valence in studies of visual scenes (Lang, 1994; Mattek et al., 2017), in some emotion lexicons (Ćoso et al., 2019; Yao et al., 2017), and in sentiment analysis of social media data (Chen & Yik, 2022). Perhaps the V-shape occurs generally in all subjective experience. Alternatively, the valence-arousal relationship might vary with domain, or with culture and language, or with individuals. When attempting to map valence to certain brain regions such as the orbitofrontal cortex and arousal to other regions such as the amygdala, researchers have reported inconsistent findings across studies (Colibazzi et al., 2010; Lindquist et al., 2012; Posner et al., 2009). Any variability in the valence-arousal relationship might explain this inconsistency in studies of the neural basis of affect. In short, the valence-arousal relationship in self-reported subjective experience needs to be better understood.

Several relationships between valence and arousal in self-reported affect have been suggested and tested (Kuppens et al., 2013, 2017). Prominent theoretical models are displayed in Figure 1.

Model 1: Independence

Valence is often assumed to be independent of arousal in self-reported affect (e.g., Barrett & Russell, 1999; Carver & Scheier, 1990; Larsen & Diener, 1992; Yik et al., 2011). In this model, how pleasant or unpleasant one is feeling provides no information about how aroused one is feeling and vice versa.

Model 2: Linear Relation

A second model posits a linear relationship, i.e., in the extreme, valence equals arousal. On one version of this model–positive correlation version–affect is one dimension ranging from sadness (negative valence, low arousal) to excitement (positive valence, high arousal). An interesting possibility is that this model applies mainly to Western societies as reflected in a preference for highly aroused pleasant affect (Tsai et al., 2006).

The alternative version of this model–negative correlation version–is that affect is one dimension ranging from tension (negative valence, high arousal) to calmness (positive valence, low arousal). This model was assumed in the psychoanalytic theory in which pleasure was thought to originate from the release of tension and in the behaviorist theory that reinforcement is the reduction of drive. An interesting possibility is that this model applies mainly to Asian societies as reflected in a preference for deactivated pleasant affect (Tsai et al., 2006).

Model 3: Symmetric V-Shaped Relation

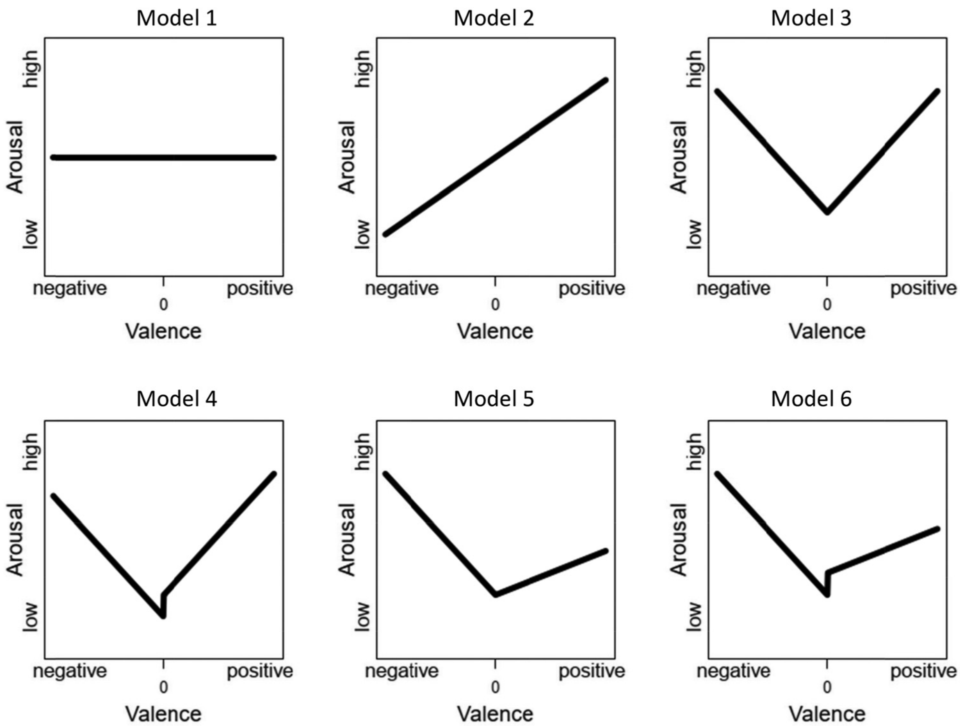
In this model, arousal is minimal at neutral valence and then increases with (or is) the intensity of positive and, separately, of negative valence. The relation is symmetric with positive and negative valence having an equal intercept on the arousal axis and slope values equal in magnitude but opposite in sign. Model 3 is commonly thought of as the V-shaped relationship shown in Figure 1. Here, we also allow Model 3 to include an inverted V-shaped relationship. Model 3 resonates with Gray's (1987) theory of two independent motivational systems–behavioral activation and inhibition–in which arousal is the intensity of each system and with Thayer's (1989) theory of two different types of arousal, one positive and one negative.

Models 4–6: Asymmetric V-Shaped Relation

Models 4 through 6 are based on the evaluative space model (Cacioppo & Berntson, 1994). These models are similar to Model 3, but with asymmetries. Model 4 adds a positivity offset: positive valence begins at a higher level of arousal than does negative valence. That is, the curves for positive and negative valence have different intercepts on the arousal axis.

Model 5 adds a different asymmetry: differences in the slopes for positive versus negative valence. For instance, Ito and Cacioppo (2005) argued that arousal increases more strongly with negative valence than it does with positive valence (something that they called negativity bias). The opposite can in principle also occur, namely that arousal increases more strongly with positive valence. Both intercept and slope asymmetries appear in Model 6.

Figure 1
Six Possible Relations Between Valence and Arousal



Note. Model 1 is the independence model: Valence is independent of arousal. In Model 2, a linear relation is assumed allowing for valence to increase linearly with arousal. Model 3 assumes a symmetric V-shaped relation so that arousal may increase with the intensity of positive, and separately, of negative valence. Model 4 permits an asymmetric relation with different intercepts so that positive valence may begin at a higher level of arousal than does negative valence. In Model 5, an asymmetric V-shaped relation with different slopes is assumed; arousal may increase more strongly with negative compared with positive valence or vice versa. Model 6 combines Models 4 and 5 resulting in an asymmetric V-shaped relation with different intercepts and different slopes.

Cultural Variations in the Valence-Arousal Relationship

In addition to the different theoretical models, the empirical evidence in favor of or against these models has been inconsistent as well (see Kuppens et al., 2013, for a detailed discussion). Part of this inconsistency may arise because the relation between valence and arousal may differ with the stimulus condition, with the culture or language, or even with the person examined. Indeed, Kuppens et al. (2013) tested the six theoretical models by deploying multilevel regression models that incorporate both a nomothetic (i.e., population) structure and idiographic variations in the nomothetic structure (i.e., individual differences modeled as random effects). They found support for asymmetric V-shaped relationships (Models 5 and 6) in eight samples of English speakers at the nomothetic level, but the relationship at the population level was weak and showed large variations at the idiographic level, implying perhaps the valence-arousal relationship can vary from one sample to the next.

To complement the data from English-speaking societies, Kuppens et al. (2017) examined data from another five societies. In contrast to prior findings, Kuppens et al. supported a symmetric V-shaped relationship (Model 3) in all but Hong Kong (Model 1). The slope was steepest for Western cultures (Canada, Spain) but less steep (Japan, Korea) to almost flat (Hong Kong) for Eastern cultures.

Clearly more cross-cultural data are needed. Therefore, in the present study, we sought to test the six models on a large cross-cultural network involving 33 samples. They span six continents and cover the global regions identified by Schwartz (2006).

Measurements of Self-Reported Momentary Affect

The variety of measures used in the past studies complicated the examination of the valence-arousal relationship. Valence and arousal have been measured in various ways such as with the Self-Assessment Manikin (Bradley & Lang, 2007) or the Affect Grid (Russell et al., 1989). Kuppens et al. (2013) used items tapping pleasure, displeasure, high arousal, and low arousal. In the present study, we adopted Kuppens et al.'s method by asking the participants to report their affect using affect items covering pleasant, unpleasant, activated, and deactivated. We then tested structural invariance of the two constructs, namely valence (defined by pleasant and unpleasant items) and arousal (defined by activated and deactivated items), across the 33 samples.

The instructions for self-reported affect in the past studies have been problematic. Sometimes, the participant was asked about his or her affect over an extended period of time (today, this week, etc.), but affective feelings ebb and flow, sometimes changing quickly. Participants were sometimes asked to rate their feelings during a specific type of remembered episode or their reactions to a set of stimuli such as tunes or pictures; such ratings have restricted variance and likely lack the social complexity of everyday life. In other cases, participants simply responded to a questionnaire, with questions such as "How are you feeling right now?." The variance in such ratings is likely restricted because all participants are in the same circumstance, such as filling out a questionnaire, or perhaps sitting in a boring lab.

Here we focus on momentary affect. To capture everyday momentary feelings, experience sampling would be ideal, although it can be costly becoming a stumbling block to large-scale cross-cultural projects. An alternative to experience sampling is to measure affect in a broader range of moments. In the present study, a "remembered moments" questionnaire (RMQ) was used in which participants recalled a clear moment from the day before (see Yik et al., 2002; see the day Reconstruction Method developed by Kahneman et al., 2004). The moments from the RMQ method are likely to be varied and representative of experiences outside the lab. Of course, memory is fallible, and so the RMQ is designed to have the participant select a well-remembered moment.

Method

Samples and Participants

The 33 datasets collected cover six continents, using translations into 25 different languages including Indo-European (Croatian, Czech, Dutch, English, French, German, Greek, Icelandic, Italian, Polish, Portuguese, Romanian, Russian, Serbian, Slovak, and Spanish), Afro-Asiatic (Arabic, Hebrew), Uralic (Estonian, Finnish), Austroasiatic (Vietnamese), Austronesian (Indonesian), Japonic (Japanese), Koreanic (Korean), and Sino-Tibetan (Chinese). For feasibility, we intended to recruit 200 participants per sample.[1] A total of 8,590 university students (59% female) took part in the study during February to November 2018. Sample sizes ranged from 190 (Belgium, Nigeria) to 469 (Czech Republic). All participants were at least 16 years of age, with an overall mean of 24.01 years (*SD* = 7.67). For the demographic characteristics of the samples, please refer to the online Supplemental Materials 1.

Procedure

We are a team of researchers involved in cross-cultural projects (see McCrae et al., 2005). All researchers involved in this project are fluent in English and have extensive experience collaborating in large-scale survey research projects and translating questionnaires into their own languages. For non-English speaking samples, each researcher received an English questionnaire package for translation purpose. A standardized translation and back-translation procedure was used to prepare different language versions. For each language, we recruited two bilinguals; the first bilingual translated the English items into the target language and the second bilingual independently back-translated the items into English. Discrepancies between the original and back-translated English versions were identified, discussed, and reconciled.

Participants were asked to complete nine questionnaires including the one reported in this article; average completion time was 35 min. Most data were collected online using Qualtrics (25 samples), with a few samples using the paper-pencil method (four samples), or both methods (four samples). The study was approved by the HKUST Human Participants Research Panel. All data were collected in accordance with the local ethical guidelines and procedures.[2]

Upon the completion of data collection, collaborators provided details on the sample description, the data collection method, and unexpected events, if any, during the data collection. The initial sample consisted of 8,642 participants among whom 52 cases were excluded in data screening resulting in a final sample of 8,590 participants for subsequent analysis.[3]

Instructions and Measures

Participants were asked to recall a clearly remembered moment from the day before: "Please think back to yesterday. Search your memory for a particular moment that is especially clear in your memory. Let's call it your clearest moment." To help the participants to relive the moment, they were asked to think about the time, location, the person they were with, and things that they were doing during this clearest moment.

They then rated their feelings during that moment using 16 affect adjectives. The 16 adjectives were culled from four affect segments of the 12-Point Affect Circumplex (12-PAC; Yik et al., 2011).[4] Valence was tapped by four pleasant items ("happy," "pleased," "content," and "satisfied") and four unpleasant items ("miserable," "unhappy," "troubled," and "dissatisfied"), whereas arousal was tapped by five activated items ("determined," "intense," "hyperactivated," "aroused," and "activated") and three deactivated items ("still," "quiet," and "sleepy"). Participants rated their affect on a 5-point Likert scale ranging from 1 (*not at all*) to 5 (*extremely*). The median values of the alpha coefficients ranged from .50 (deactivated) to .93 (pleasant). For details, please refer to the online Supplemental Materials 2.

Results and Discussion

The data were processed and analyzed in four steps: In a first step, we determined measurement-invariant scales for valence and arousal across the 33 samples. In a second step, we calculated valence and arousal scores per participant. The resulting data were then analyzed to determine the valence-arousal relation and cultural variations therein. To this end, in a third step, we first fit models each representing a different theoretical model to the data of each sample separately, and then identified the dominant patterns across the 33 samples. In a final and fourth step, we fit a

[1] After data collection, we found that a power analysis using an effect size of 8% found in Study 1c in Kuppens et al. (2013) indicated that the sample of 200 achieves .95 power with $\alpha = .05$.

[2] University ethics approval was required and obtained in 11 samples.

[3] Four were eliminated because they left blank all items on at least four questionnaires administered. Another 48 were eliminated because they used the same response option for all items for at least two of the nine questionnaires.

[4] Male and female versions were developed for the affect measure in 14 of 25 languages where there are masculine and feminine adjectives.

(multilevel) model that allows for these dominant patterns across all participants from all samples (N = 8,590). This model allows us to identify what an overall, pancultural relation between valence and arousal would look like, how much of the total variance such a pancultural model could explain the degree to which each sample might deviate from this overall model.

Step 1: Measurement Invariance

To evaluate the invariance of measures for valence and arousal across the 33 samples, we tested configural invariance (factor loadings and intercepts freely estimated across groups) and metric invariance (factor loadings constrained to be equal across groups) to ensure the meaning of the latent construct was equal across groups. For details of the procedure, please refer to the online Supplemental Materials 3.

Figure 2 presents the final model consisting of 11 items with two correlated residuals. The model fit of the metric invariance model was compared with the configural model. Metric invariance across the samples is indicated when imposing invariant factor loadings leads to no more than .02 decrease in comparative fit index (CFI), no more than .03 increase in root mean square error of approximation (RMSEA; Rutkowski & Svetina, 2014), and no more than .02 increase in standardized root mean square residual (SRMR; Chen, 2007). The changes of the fit measures between the two models were small (ΔCFI = .018, ΔRMSEA = .003, ΔSRMR = .033) indicating that the factor loadings are equal across groups and thus metric invariance holds. Therefore, the comparison of the linear valence-arousal relation across the samples can be carried out. Significant positive covariances were observed in all 33 samples, with covariances ranging from .19 (Finland) to .86 (Indonesia) in the metric invariance model. For details, please refer to the online Supplemental Materials 4 and 5. This step resulted in the identification of the items to define a valence score and an arousal score per participant.

Step 2: Calculation of the Final Valence and Arousal Scores

The theoretical and mathematical models used to capture the various possible relations between valence and arousal make use of a neutral valence midpoint (forming the deflection point of any asymmetric relation). Consequently, it was not possible to use the factor scores from the abovementioned final factor analytic model as input for the analyses modeling the relation between valence and arousal, as the point at which the factor scores equal zero cannot be assumed to reflect neutral valence. To circumvent this problem, using the 11 items in Figure 2, we calculated valence and arousal scores per participant by subtracting the average of the negative valence items from the average of the positive valence items, and the low arousal item from the average of the high arousal items, respectively (similar approach was used by Kuppens et al., 2013, 2017).

Step 3: Best Fitting Model for Each Sample

We first examined the relationship between these valence and arousal scores within each sample. In each sample, we fit six different statistical regression models in which arousal was modeled as a function of valence in correspondence with the theoretical relations from Figure 1. The models we fit to the data, however, allowed more variation of values than those shown in Figure 1. For example, the "Model 3" we fit to the data allowed an inverted V as well as the V-shape shown in Figure 1; the "Model 5" we fit to the data allowed various slope values as well as the steeper slope for negative valence shown in Figure 1. In addition, for more flexibility, we included an additional nonparametric model (Model 7) that does not make prior parametric assumptions (see Kuppens et al., 2013, for more details on the statistical models).

To select the model that provides the most appropriate fit to the data in each sample, we relied on the Bayesian information criterion (BIC) and posterior model probabilities derived from the BIC (Raftery, 1995). The best fitting model has the lowest BIC score and highest posterior model probability (see Kuppens et al., 2013). For each sample, the seven models were estimated, separately, and the best fitting model was selected. Table 1 presents the model selection indices and Table 2 the best fitting model for each sample. Figure 3 shows the plotted data between valence and arousal together with the best fitting model separately for each sample.

No one model showed the best fit in all 33 samples: different samples were best characterized by different models. However, only four models emerged as best fitting. Model 2 emerged in 14 samples, with arousal increasing linearly with valence. In the remaining 19 samples, models including an asymmetry were selected: 16 samples included a V-shape relationship with a steeper slope for positive valence (Model 5), two included a higher intercept for positive valence (Model 4), and one included both a lower intercept and a steeper slope for positive valence (Model 6).

Figure 2
The Final Two-Factor Model for Which Metric Invariance Holds

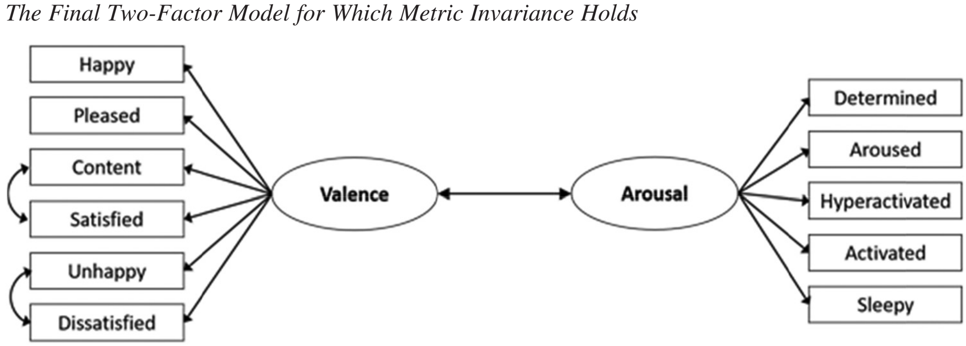


Table 1
Summary of Model Selection Indices When Arousal is Modeled as a Function of Valence

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6		Model 7	
	Independence		Linear relation		Symmetric V		Asymmetric V with different intercepts		Asymmetric V with different slopes		Asymmetric V with different intercepts, different slopes		Nonparametric	
Region/sample[a]	BIC	PostP	BIC	PostP	BIC	PostP	BIC	PostP	BIC	PostP	BIC	PostP	BIC	PostP
Full data set	33,532.27	.00	31,805.94	.00	32,422.25	.00	31,843.74	.00	**31,554.87**	**.99**	31,563.24	.01	31,586.78	.00
Africa and the Middle East														
Nigeria	620.66	.00	572.08	.01	569.05	.05	**563.71**	**.79**	568.34	.08	568.77	.06	573.76	.01
Oman	815.38	.00	**774.73**	**.70**	777.57	.17	782.70	.01	778.43	.11	783.70	.01	784.42	.01
Uganda	699.26	.00	**601.22**	**.69**	633.63	.00	607.67	.03	603.69	.20	607.62	.03	606.51	.05
Confucian														
China (Beijing)	822.59	.00	717.84	.01	770.85	.00	727.10	.00	**709.39**	**.89**	714.74	.06	715.54	.04
China (Hong Kong)	1,035.41	.00	960.35	.00	986.77	.00	955.55	.01	**946.10**	**.88**	950.68	.09	954.02	.02
Japan	1,013.45	.00	**989.64**	**.75**	1,001.35	.00	997.95	.01	992.33	.20	997.85	.01	996.71	.02
South Korea	1,056.80	.00	1,028.53	.00	1,015.52	.11	1,019.60	.01	**1,012.20**	**.58**	1,014.01	.24	1,016.77	.06
East Europe														
Croatia	899.84	.00	860.07	.17	869.86	.00	859.48	.23	**858.07**	**.46**	863.19	.04	861.14	.10
Czech Republic	1,942.60	.00	1,848.63	.09	1,915.72	.00	1,874.53	.00	**1,844.70**	**.62**	1,846.88	.21	1,848.73	.08
Estonia	856.17	.00	823.89	.26	833.50	.00	824.47	.20	**822.73**	**.47**	827.49	.04	828.67	.02
Poland	1,560.32	.00	**1,507.40**	**.42**	1,545.42	.00	1,508.94	.19	1,507.97	.31	1,511.87	.04	1,512.82	.03
Romania	931.11	.00	**856.26**	**.74**	929.75	.00	891.14	.00	860.75	.08	859.13	.18	864.75	.01
Russia	987.44	.00	961.12	.05	969.14	.00	**956.93**	**.43**	956.93	.43	961.13	.05	962.65	.02
Serbia	883.41	.00	815.00	.00	834.88	.00	809.00	.03	**802.19**	**.90**	807.23	.07	819.26	.00
Slovakia	1,007.14	.00	966.60	.03	980.91	.00	965.23	.07	**960.18**	**.82**	965.65	.05	966.57	.03
English-speaking														
Australia	940.79	.00	**906.05**	**.88**	922.22	.00	920.66	.00	911.57	.06	917.02	.00	911.49	.06
Israel	833.46	.00	781.06	.30	799.38	.00	789.53	.00	**779.68**	**.61**	784.92	.04	785.02	.04
New Zealand	1,671.69	.00	1,631.36	.10	1,645.39	.00	1,640.11	.00	**1,627.38**	**.75**	1,631.84	.08	1,632.16	.07
United Kingdom (England)	790.38	.00	**748.26**	**.45**	781.11	.00	759.26	.00	748.27	.45	753.51	.03	752.37	.06
United States	994.00	.00	**968.94**	**.76**	981.48	.00	972.87	.11	972.65	.12	976.76	.02	985.19	.00
Latin America														
Brazil	918.63	.00	**865.85**	**.72**	902.75	.00	886.33	.00	868.28	.21	872.85	.02	871.15	.05
Colombia	1,066.42	.00	937.70	.20	1,018.39	.00	962.68	.00	**935.13**	**.74**	940.73	.04	943.28	.01
South Asia														
Indonesia	1,392.45	.00	1,266.55	.12	1,344.17	.00	1,298.72	.00	**1,262.66**	**.84**	1,268.51	.04	1,280.67	.00
Vietnam	925.21	.00	**882.56**	**.80**	902.38	.00	900.27	.00	887.39	.07	891.48	.01	886.38	.12
West Europe														
Belgium	723.13	.00	700.96	.03	698.10	.12	697.02	.20	**694.84**	**.60**	700.05	.04	702.99	.01
Finland	840.68	.02	**834.17**	**.63**	836.12	.24	841.25	.02	838.41	.08	841.80	.01	843.66	.01
France	1,093.98	.00	1,063.91	.01	1,069.29	.00	1,060.92	.04	**1,054.67**	**.86**	1,059.75	.07	1,061.59	.03
Germany	837.19	.00	**803.55**	**.50**	825.45	.00	804.26	.35	807.75	.06	808.91	.03	808.30	.05
Greece	1,208.86	.00	1,122.73	.00	1,151.27	.00	1,128.22	.00	1,101.11	.43	**1,100.56**	**.57**	1,111.10	.00
Iceland	1,228.70	.00	1,204.55	.03	1,200.01	.33	1,203.51	.06	**1,199.24**	**.49**	1,203.68	.05	1,204.39	.04
Italy	933.98	.00	**866.30**	**.50**	909.68	.00	886.42	.00	866.56	.44	871.18	.04	873.62	.01
Spain	807.61	.00	766.31	.03	769.99	.00	764.73	.06	**759.36**	**.85**	764.64	.06	774.81	.00
Switzerland	862.32	.00	**827.23**	**.84**	849.61	.00	837.45	.01	831.08	.12	836.52	.01	834.10	.03

Note. BIC = Bayesian information criterion (lower values reflect better fit). PostP indicates posterior probability of each model given the data among the set of seven models. The fit indices of the best-fitting are underlined and bold.
[a] Global regions were identified by Schwartz (2006).

In short, two models dominated in 30 of the 33 samples: Model 2 in 14 samples and Model 5 in 16 samples. In about half of the samples, slopes differed by valence: Positive valence uniformly showed a strong positive slope with arousal, but negative valence showed slopes ranging from negative to flat to positive.

The finding of the main support for Models 2 and 5 should be understood against the background of the large variations in the valence-arousal relationship within each sample (as evident in the scattered data points in the 33 plots in Figure 3). As shown in the next-to-last column of Table 2, the variance accounted for by the best fitting model was often low, with R^2 values ranging from .05 (Model 2 for Finland) to .43 (Model 5 for China Beijing). Thus, explanatory power of even the best fitting model in which arousal is a function of valence was often low, and within each sample there remains much variation around the overall relation.

Step 4: One Model for All 33 Samples

We next evaluated the possibility of one pancultural model to describe the relation between valence and arousal. As a first step in exploring this possibility, we collapsed the data across samples. With the pooled data of 8,590, we fit the seven theoretical models to the data. The results are shown in the first line of Table 1. Our version of Model 5 (in which we allowed empirically determined values for the two slopes) provided the best fit. Another considera-tion also favored Model 5: Within each separate sample, both

Table 2
Overview of Best Fitting Model for the Relation Between Valence and Arousal (in Comparison With the Fixed Effects Part of the Multilevel Extension of Model 5)

Region/sample[a]	Best model	Relation	Higher intercept	Steeper slope	R^2 for the best fitting model	R^2 based on the fixed effects of Model 5[b]
Africa and the Middle East						
Nigeria	4	Asymmetric V	Positive valence	—	.21	.18
Oman	2	Linear/positive	—	—	.14	.14
Uganda	2	Linear/positive	—	—	.24	.25
Confucian						
China (Beijing)	5	Asymmetric V	—	Positive valence	.43	.43
China (Hong Kong)	5	Asymmetric V	—	Positive valence	.31	.31
Japan	2	Linear/positive	—	—	.11	.12
South Korea	5	Asymmetric V	—	Positive valence	.19	.17
East Europe						
Croatia	5	Asymmetric V	—	Positive valence	.18	.18
Czech Republic	5	Asymmetric V	—	Positive valence	.21	.21
Estonia	5	Asymmetric V	—	Positive valence	.18	.18
Poland	2	Linear/positive	—	—	.13	.14
Romania	2	Linear/positive	—	—	.30	.29
Russia	4	Asymmetric V	Positive valence	—	.16	.16
Serbia	5	Asymmetric V	—	Positive valence	.33	.33
Slovakia	5	Asymmetric V	—	Positive valence	.21	.21
English-Speaking						
Australia	2	Linear/positive	—	—	.15	.14
Israel	5	Asymmetric V	—	Positive valence	.27	.27
New Zealand	5	Asymmetric V	—	Positive valence	.12	.12
United Kingdom (England)	2	Linear/positive	—	—	.21	.23
United States	2	Linear/positive	—	—	.11	.12
Latin America						
Brazil	2	Linear/positive	—	—	.22	.23
Colombia	5	Asymmetric V	—	Positive valence	.41	.41
South Asia						
Indonesia	5	Asymmetric V	—	Positive valence	.33	.32
Vietnam	2	Linear/positive	—	—	.13	.12
West Europe						
Belgium	5	Asymmetric V	—	Positive valence	.18	.18
Finland	2	Linear/positive	—	—	.05	.05
France	5	Asymmetric V	—	Positive valence	.16	.15
Germany	2	Linear/positive	—	—	.16	.16
Greece	6	Asymmetric V	Negative valence	Positive valence	.33	.31
Iceland	5	Asymmetric V	—	Positive valence	.12	.12
Italy	2	Linear/positive	—	—	.27	.28
Spain	5	Asymmetric V	—	Positive valence	.22	.21
Switzerland	2	Linear/positive	—	—	.16	.16

[a] Global regions were identified by Schwartz (2006). [b] See Table 3 for the multilevel extension of Model 5.

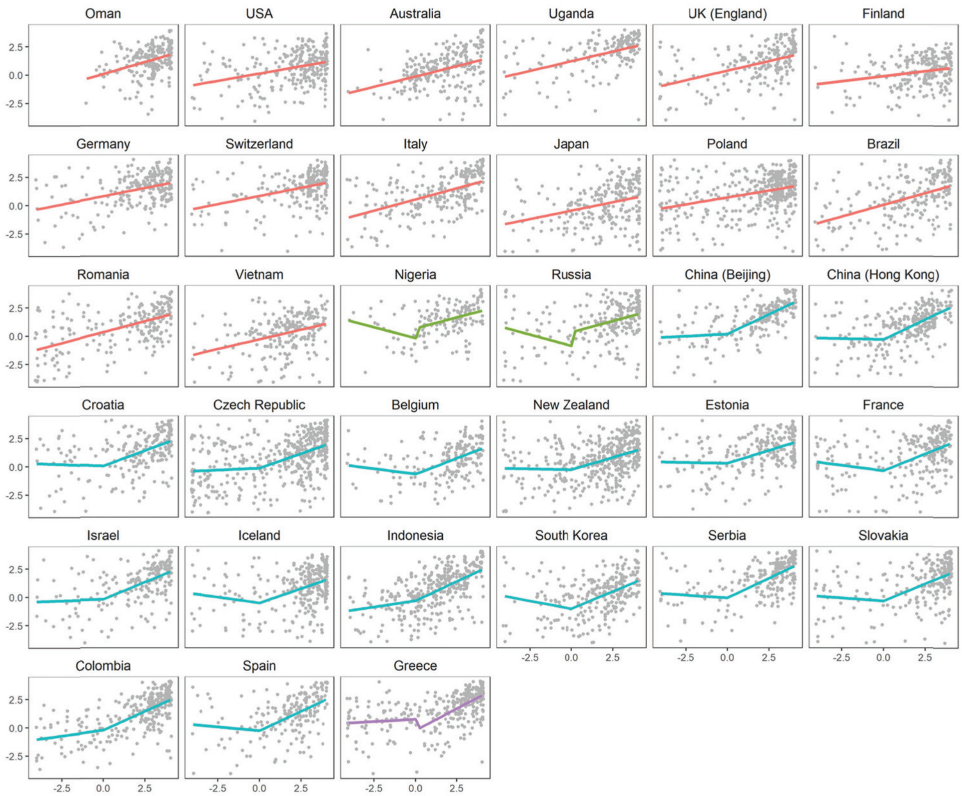
Model 5 and Model 2 had emerged as best fitting. Nonetheless, Model 2 can be thought of as a special case of Model 5: Model 2 adds the constraint that the slope of negative valence is equal in magnitude to the slope of positive valence. Model 5 is thus the more general model, and the frequency of finding an asymmetry in slope values led us to Model 5.[5] Thus, Model 5 is the best candidate for a nomothetic structure of affect. The version of Model 5 that fit the total sample is shown in the thick black line of Figure 4. As can be seen in this figure, this version features a positive slope for positive valence, and an almost flat slope for negative valence.

To account for between-sample differences in this overall relation, a multilevel extension of Model 5 was also estimated. The multilevel framework allowed us to model an overall, population-average relation between valence and arousal across the data from all 33 samples (i.e., the fixed effects structure), and at the same time to estimate sample-specific deviations from this average relation (i.e., the random effects structure). Indeed, the fixed effects pertaining to the intercept and slope values of this population average-model reveal the shape of the average model across all samples, and the random effects pertaining to the intercepts and slopes allow for variation between samples. Table 3 shows the numerical estimates of the model, and Figure 5 displays the estimated fixed effects part of the model, portraying the population average model across all 33 samples, together with sample-specific deviations. Across all data, the marginal R^2 of this model (i.e., the proportion of variance explained by the fixed effects alone) equals .19, and the conditional R^2 (i.e., the proportion of

[5] Model 6 was also a reasonable candidate to explore as a pancultural model for all samples. After all, Model 6 is the most general of the models. Model 6 is equivalent to Model 5 but allows different intercepts for positive and negative valence (viz., an offset). The offset occurred in the best fitting model for only three of the 33 samples, and in one of those the value of the intercept was opposite to that predicted by Cacioppo and Berntson (1994). Offset thus seemed to be an unlikely feature of the general model we sought.

Figure 3

Relationship Between Valence and Arousal in Each Sample With the Best Fitting Model



Note. The panels are ordered from the simplest to the most complex models. Colors are used to differentiate between the best models (red for Model 2 for Oman to Vietnam, green for Model 4 for Nigeria and Russia, blue for Model 5 for China Beijing to Spain, and purple for Model 6 for Greece).

variance explained by both the fixed and random factors) equals .25 (see Nakagawa et al., 2017).[6] These results mean that taking the fixed part of the model only (i.e., assuming equal intercept and slopes across samples) explains 19% of the total variance observed across all participants. Allowing sample-specific deviations in these parameters increases this value to 25% of the total variance.

The multilevel extension of Model 5 underscores three points about the population-average, pancultural model. First, as shown in Table 3 and in the thick black line in Figure 5, the intercept of the model is close to the arousal midpoint (i.e., not significantly different from zero). Second, the model contains different slopes for positive and negative valence. Specifically, the slope of negative valence is flat whereas the slope of positive valence was significantly steeper than the slope for negative valence. Three, despite this overall relation, there is variation among the samples in the parameters (see also the thin lines in Figure 5). The appearance of variation was confirmed by the sizable sample-specific deviations from the fixed effects structure as indicated by the variance components of the multilevel model. There is considerable variation across samples for the intercept, the negative valence slope, and the positive valence slope.

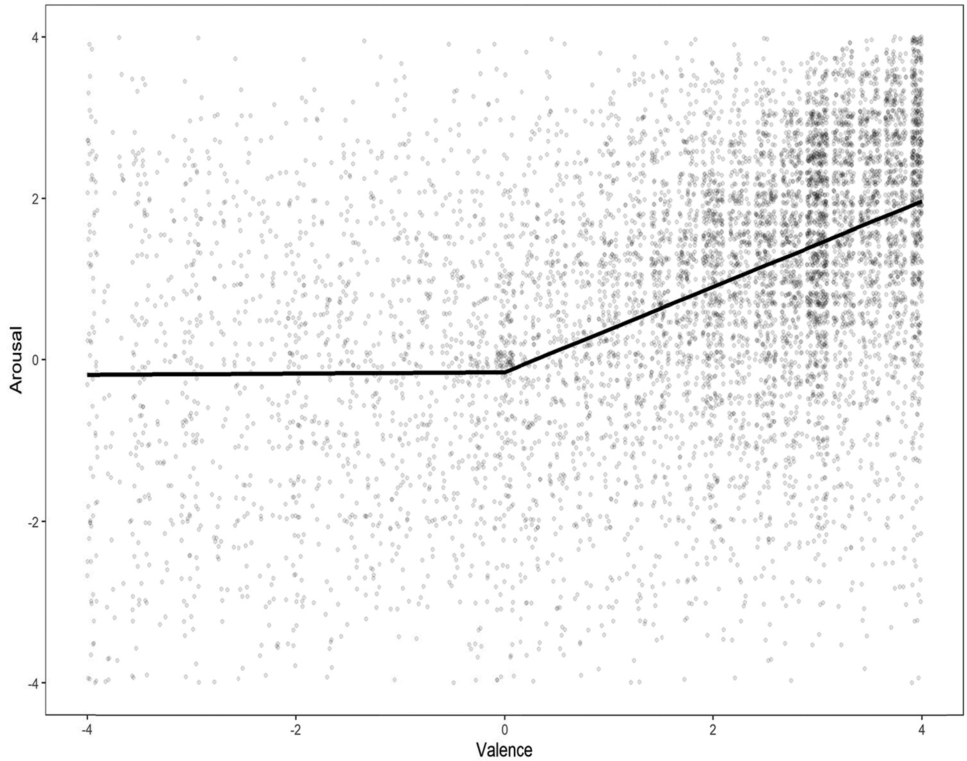
Finally, one may wonder how allowing for sample-specific deviations (as in the sample specific models or the multilevel model reported above) compares to an approach that would assume the exact same relation between valence and arousal in every sample. To evaluate this possibility, we estimated the proportion of explained variance per sample if one would fit the same model dictated by the fixed effects portion of Model 5 (with a positive slope for positive valence and a flat slope for negative valence; see Table 3 and the bold line in Figures 4 and 5) to the data from each sample. To do so, we examined the squared correlation between the observed arousal values and the arousal values predicted by the fixed effects component of the multilevel model. The R^2 values are reported in the last column of Table 2. The possibility of a single model with no sample-specific parameters was supported by the similarity of these R^2 values to those from the separate different models per country (the last second column of Table 2).

Conclusion

Model 5–our version as seen in the thick black line of Figure 4 or 5–provides a reasonably good fitting general model, an average

[6] We opted here for a naive calculation of R^2 in the multilevel model by calculating r^2 (observed y, predicted y), which is the squared correlation between the observations and the predictions from the model. The predictions come from the fixed effects part of the model only (i.e., the marginal R^2) or from the fixed plus random effects part (i.e., the conditional R^2).

Figure 4
Relationship Between Valence and Arousal Based on an Overall, Nonmultilevel Model 5



global relationship between valence and arousal across our 33 samples and among our 8,590 participants. Such a general model is useful for many purposes. If, of a group of participants, all we know is that they are human, then this version of Model 5 is a good basis for the description of their momentary affect: When they are feeling pleasant, they tend to be feeling activated; When they are feeling unpleasant, they could be feeling activated, deactivated, or in between. More generally, the average global relationship between valence and arousal is asymmetric, with an almost flat slope for negative valence that is joined to a positive slope for positive valence. Model 5 is the prime candidate for a universal pancultural account of the general relation between valence and arousal.

The flat slope for negative valence might possibly be explained, in part, by two reasons. One was related to memory recall. Our participants tended to remember positive valence, and this effect is vividly evident in all 33 plots in Figure 3.[7] In the most extreme case, people in Oman almost never recalled any negative valence. Certainly this does not mean that they never experience anything negative. Rather they did not report negative valence. Positivity bias in memory recall was well documented in the literature supporting the prevalence of pleasant (vs. unpleasant) events (see Botzung et al., 2010). Others have found that the affect associated with unpleasant memories fades faster than that associated with pleasant memories (see Ritchie et al., 2015). The intersection between memory recall and the valence-arousal model should be included in future research directions.

The second reason for the flat slope could be related to the word choice. In English, most of the words used to anchor arousal appear to be positive (e.g., "determined" and "aroused"). The positivity of these words could bias our results to show that arousal and positive valence are correlated, but arousal and negative valence are not. When we chose the words to define arousal in English, we sought to focus on those saturated with arousal and relatively independent of valence. (To maintain the independence of valence and arousal in the translations, detailed instructions were given to the translators in the remaining 24 languages.) To test the positivity bias of the arousal words, we estimated the correlations between the four high arousal items ("determined", "aroused", "hyperactivated", and "activated") and the positive valence score in each of the 33 samples: The mean correlation was .32 (*SD* = .15) for "determined", .35 (*SD* = .20) for "aroused", .41 (*SD* = .09) for "activated", and .30 (*SD* = .14) for "hyperactivated" (in the United States sample, the corresponding values were .06, .32, .27, and .13.) These positive correlations might be due to the co-occurrence of higher arousal with positive valence, or to a semantic relationship such that these four high arousal words have some component of positive valence, or to the memory bias discussed above. Our results lent some potential support that word choice is one possible explanation for our global model, but co-occurrence of positive valence and arousal is also possible. The differences in correlations across the four arousal items (.30 to .41) are consistent with both factors influencing the results. So, for now, we can conclude that positive valence is positively correlated with arousal. It remains for future research to

[7] The 1,589 subjects fell in the negative valence region where the correlation between valence and arousal was .02 ($p = .40$).

Table 3
Results of the Multilevel Extension of Model 5

Parameter	Fixed effects				Random effects (variance components)	
	Estimate	*SE*	*t* (*df* = 8,446)	*p*	*SD*	95% CI
Intercept	−.10	.07	−1.49	.137	.32	[.21, .43]
Negative valence slope	−.03	.03	−1.08	.279	.08	[.03, .14]
Positive valence slope	.55	.03	18.94	<.001	.13	[.07, .18]

Note. The 95% confidence interval (CI) for the standard deviation of the random effects are generated using a parametric bootstrap procedure (van der Leeden et al., 2008, p. 410; see also Pinheiro & Bates, 2000).

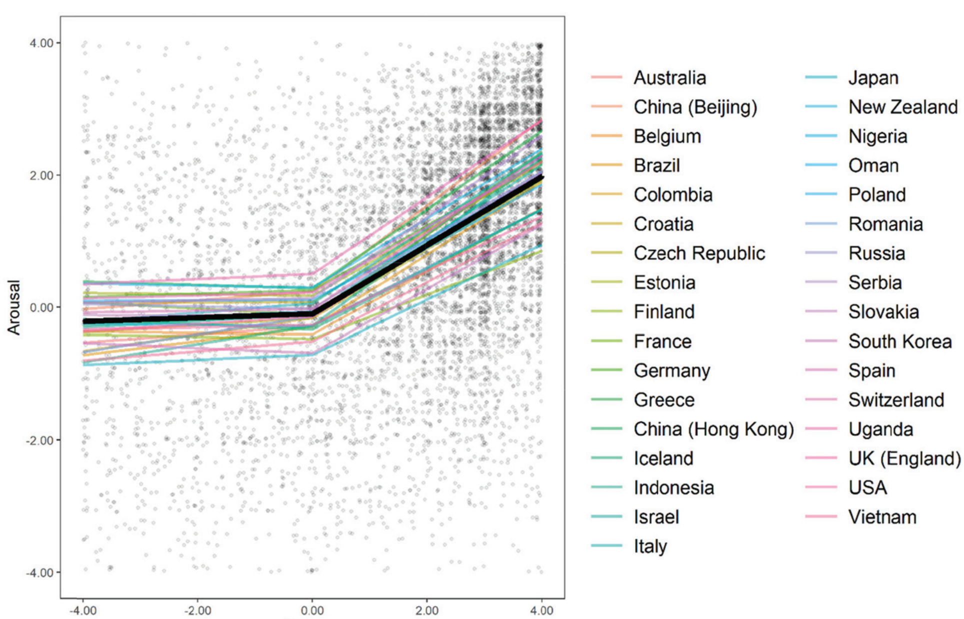
determine how much of that correlation is due to general co-occurrence of positive valence and arousal in daily life, how much to semantics of the items used, and how much to a memory bias as discussed above.

A more precise model is possible for each separate sample. That is, as also shown in Figure 5, we also found evidence for differences among the 33 samples—differences that can be represented simply by three parameters: (a) the value of arousal at neutral valence, (b) the slope of arousal as a function of positive valence, and (c) the slope of arousal as a function of negative valence. Specifying values for each of these three parameters for a specific sample provides a better fitting model of affect. Why each parameter takes on the value it does for a given sample remains to be seen, however. This question rises to the top of the list of important directions for future research. Of course, simply sampling differences might have occurred, but more interesting possibilities are differences between samples in terms of personality, culture, language, geography, and social differences.

One possibility–suggested by results shown in Figure 3–is that more than these three parameters are needed because the relationship of valence to arousal varies even more with sample when modeled separately. As shown in Figure 3, for example, the best fitting model for both Nigeria and Russia has a positivity offset and a positive slope of arousal as a function of the intensity of negative valence—a combination of features not seen in the best fitting model for any other society. The best fitting model for 19 samples has an inflection point such that the arousal slope changes from negative to positive valence, and yet no inflection point occurred for the other 14 samples. Such differences are more likely than the three parameters of Figure 5 to be due to sampling differences, and yet they are hints of interesting possibilities. In these cases, replicability is the first question.

Certain negative conclusions are also warranted. In no sample did the independence model (Model 1 of Figure 1) provide the best fit. This finding in itself is important, as it indicates that the model most commonly presupposed in measures of self-reported affect is only an approximation. On the other hand, for no sample

Figure 5
Relationship Between Valence and Arousal Based on the Multilevel Extension of Model 5



Note. The population average (i.e., fixed effects) is shown as the thick black line; the sample-specific relations (fixed plus random effects) are shown as the colored thin lines.

did valence account for a large amount of variance in arousal scores. In other words, the consistently low values of R^2 for even the best fitting model in each sample and the overall model in all 8,590 participants support a fair amount of independence between valence and arousal. In addition, for the single best average model of Figures 4 or 5, arousal was independent of negative valence. That average model or the version with three parameters must therefore be interpreted against the background of the low degree of predictive strengths of the best fitting model within each sample. Therefore, these prevalent relationships seen here should be interpreted in a probabilistic rather than deterministic manner. For any individual, any combination between valence and arousal remains possible.

Further, we found no evidence indicating a need for highly complex models to represent the relation between valence and arousal. Of the seven models examined, only four emerged as the best fit for even one sample. Even more telling, in no sample did the nonparametric Model 7 provide the best fit. The relation between valence and arousal within and between samples can be represented by simple principles. We offer the simple model seen in Figures 4 or 5, with three parameters to represent sample differences, as the most promising account consistent with current evidence.

References

Barrett, L. F., & Russell, J. A. (1999). The structure of current affect: Controversies and emerging consensus. *Current Directions in Psychological Science*, *8*(1), 10–14. https://doi.org/10.1111/1467-8721.00003

Berlyne, D. E. (1960). *Conflict, arousal, and curiosity*. McGraw-Hill Book Company. https://doi.org/10.1037/11164-000

Botzung, A., Rubin, D. C., Miles, A., Cabeza, R., & Labar, K. S. (2010). Mental hoop diaries: Emotional memories of a college basketball game in rival fans. *The Journal of Neuroscience*, *30*(6), 2130–2137. https://doi.org/10.1523/JNEUROSCI.2481-09.2010

Bradley, M. M., & Lang, P. J. (2007). Emotion and motivation. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.), *Handbook of psychophysiology* (pp. 581–607). Cambridge University Press. https://doi.org/10.1017/CBO9780511546396.025

Cacioppo, J. T., & Berntson, G. G. (1994). Relationship between attitudes and evaluative space: A critical review, with emphasis on the separability of positive and negative substrates. *Psychological Bulletin*, *115*(3), 401–423. https://doi.org/10.1037/0033-2909.115.3.401

Cannon, W. B. (1927). The James-Lange theory of emotions: A critical examination and an alternative theory. *The American Journal of Psychology*, *39*(1/4), 106–124. https://doi.org/10.2307/1415404

Carver, C. S., & Scheier, M. F. (1990). Origins and functions of positive and negative affect: A control-process view. *Psychological Review*, *97*(1), 19–35. https://doi.org/10.1037/0033-295X.97.1.19

Chen, F. F. (2007). Sensitivity of goodness of fit indexes to lack of measurement invariance. *Structural Equation Modeling: A Multidisciplinary Journal*, *14*(3), 464–504. https://doi.org/10.1080/10705510701301834

Chen, X., & Yik, M. (2022). *Valence and arousal trajectories throughout the Wuhan lockdown during COVID-19: Evidence from sentiment analysis using Weibo data* [Manuscript submitted for publication]. Division of Social Science, Hong Kong University of Science and Technology.

Colibazzi, T., Posner, J., Wang, Z., Gorman, D., Gerber, A., Yu, S., Zhu, H., Kangarlu, A., Duan, Y., Russell, J. A., & Peterson, B. S. (2010). Neural systems subserving valence and arousal during the experience of induced emotions. *Emotion*, *10*(3), 377–389. https://doi.org/10.1037/a0018484

Ćoso, B., Guasch, M., Ferré, P., & Hinojosa, J. A. (2019). Affective and concreteness norms for 3,022 Croatian words. *Quarterly Journal of Experimental Psychology*, *72*(9), 2302–2312. https://doi.org/10.1177/1747021819834226

Gray, J. A. (1987). *The psychology of fear and stress* (2nd ed.). Cambridge University Press.

Ito, T. A., & Cacioppo, J. T. (2005). Variations on a human universal: Individual differences in positivity offset and negativity bias. *Cognition and Emotion*, *19*(1), 1–26. https://doi.org/10.1080/02699930441000120

Kahneman, D., Krueger, A. B., Schkade, D. A., Schwarz, N., & Stone, A. A. (2004). A survey method for characterizing daily life experience: The Day Reconstruction Method. *Science*, *306*(5702), 1776–1780. https://doi.org/10.1126/science.1103572

Kuppens, P., Tuerlinckx, F., Russell, J. A., & Barrett, L. F. (2013). The relation between valence and arousal in subjective experience. *Psychological Bulletin*, *139*(4), 917–940. https://doi.org/10.1037/a0030811

Kuppens, P., Tuerlinckx, F., Yik, M., Koval, P., Coosemans, J., Zeng, K. J., & Russell, J. A. (2017). The relation between valence and arousal in subjective experience varies with personality and culture. *Journal of Personality*, *85*(4), 530–542. https://doi.org/10.1111/jopy.12258

Lang, P. J. (1994). The motivational organization of emotion: Affect-reflex connections. In S. H. M. van Goozen, N. E. Van de Poll, & J. A. Sergeant (Eds.), *Emotions: Essays on emotion theory* (pp. 61–93). Psychology Press. https://doi.org/10.4324/9781315806914

Larsen, R. J., & Diener, E. (1992). Promises and problems with the circumplex model of emotion. In M. S. Clark (Ed.), *Review of personality and social psychology: Volume 13. Emotion* (pp. 25–59). Sage Publications, Inc.

Larsen, J. T., McGraw, A. P., & Cacioppo, J. T. (2001). Can people feel happy and sad at the same time? *Journal of Personality and Social Psychology*, *81*(4), 684–696. https://doi.org/10.1037/0022-3514.81.4.684

Lindquist, K. A., Wager, T. D., Kober, H., Bliss-Moreau, E., & Barrett, L. F. (2012). The brain basis of emotion: A meta-analytic review. *Behavioral and Brain Sciences*, *35*(3), 121–143. https://doi.org/10.1017/S0140525X11000446

Mattek, A. M., Wolford, G. L., & Whalen, P. J. (2017). A mathematical model captures the structure of subjective affect. *Perspectives on Psychological Science*, *12*(3), 508–526. https://doi.org/10.1177/1745691616685863

McCrae, R. R., Terracciano, A., Khoury, B., Nansubuga, F., Knežević, G., Jocic, D. D., Ahn, H.-N., Ahn, C.-K., De Fruyt, F., Gülgöz, S., Ruch, W., Ghayur, M. A., Avia, M. D., Sánchez-Bernardos, M. L., Rossier, J., Dahourou, D., Fischer, R., Shakespeare-Finch, J., Yik, M., . . . Camart, N. (2005). Universal features of personality traits from the observer's perspective: Data from 50 cultures. *Journal of Personality and Social Psychology*, *88*(3), 547–561. https://doi.org/10.1037/0022-3514.88.3.547

Nakagawa, S., Johnson, P. C. D., & Schielzeth, H. (2017). The coefficient of determination R^2 and intra-class correlation coefficient from generalized linear mixed-effects models revisited and expanded. *Journal of the Royal Society, Interface*, *14*(134), 1–11. https://doi.org/10.1098/rsif.2017.0213

Pinheiro, J. C., & Bates, D. M. (2000). *Mixed-effects models in S and S-PLUS*. Springer. https://doi.org/10.1007/b98882

Posner, J., Russell, J. A., Gerber, A., Gorman, D., Colibazzi, T., Yu, S., Wang, Z., Kangarlu, A., Zhu, H., & Peterson, B. S. (2009). The neurophysiological bases of emotion: An fMRI study of the affective circumplex using emotion-denoting words. *Human Brain Mapping*, *30*(3), 883–895. https://doi.org/10.1002/hbm.20553

Raftery, A. E. (1995). Bayesian model selection in social research. *Sociological Methodology*, *25*, 111–163. https://doi.org/10.2307/271063

Reisenzein, R. (1992). A structuralist reconstruction of Wundt's three-dimensional theory of emotion. In H. Westmeyer (Ed.), *The structuralist program in psychology: Foundations and applications* (pp. 141–189). Hogrefe & Huber Publishers.

Ritchie, T. D., Batteson, T. J., Bohn, A., Crawford, M. T., Ferguson, G. V., Schrauf, R. W., Vogl, R. J., & Walker, W. R. (2015). A pancultural perspective on the fading affect bias in autobiographical memory. *Memory*, *23*(2), 278–290. https://doi.org/10.1080/09658211.2014.884138

Russell, J. A. (2017). Mixed emotions viewed from the psychological constructionist perspective. *Emotion Review*, *9*(2), 111–117. https://doi.org/10.1177/1754073916639658

Russell, J. A., & Carroll, J. M. (1999). On the bipolarity of positive and negative affect. *Psychological Bulletin*, *125*(1), 3–30. https://doi.org/10.1037/0033-2909.125.1.3

Russell, J. A., Weiss, A., & Mendelsohn, G. A. (1989). Affect Grid: A single-item scale of pleasure and arousal. *Journal of Personality and Social Psychology*, *57*(3), 493–502. https://doi.org/10.1037/0022-3514.57.3.493

Rutkowski, L., & Svetina, D. (2014). Assessing the hypothesis of measurement invariance in the context of large-scale international surveys. *Educational and Psychological Measurement*, *74*(1), 31–57. https://doi.org/10.1177/0013164413498257

Schachter, S., & Singer, J. (1962). Cognitive, social, and physiological determinants of emotional state. *Psychological Review*, *69*(5), 379–399. https://doi.org/10.1037/h0046234

Schwartz, S. H. (2006). A theory of cultural value orientations: Explication and applications. *Comparative Sociology*, *5*(2–3), 137–182. https://doi.org/10.1163/156913306778667357

Thayer, R. E. (1989). *The biopsychology of mood and arousal*. Oxford University Press.

Tsai, J. L., Knutson, B., & Fung, H. H. (2006). Cultural variation in affect valuation. *Journal of Personality and Social Psychology*, *90*(2), 288–307. https://doi.org/10.1037/0022-3514.90.2.288

van der Leeden, R., Meijer, E., & Busing, F. M. T. A. (2008). Resampling multilevel models. In J. de Leeuw & E. Meijer (Eds.), *Handbook of multilevel analysis* (pp. 401–433). Springer. https://doi.org/10.1007/978-0-387-73186-5_11

Williams, L. J., Cote, J. A., & Buckley, M. R. (1989). Lack of method variance in self-reported affect and perceptions at work: Reality or artifact? *Journal of Applied Psychology*, *74*(3), 462–468. https://doi.org/10.1037/0021-9010.74.3.462

Wundt, W. (1998). Outlines of psychology (C. H. Judd, Trans.). Thoemmes Press. (Original work published 1897) https://doi.org/10.1037/12908-000

Yao, Z., Wu, J., Zhang, Y., & Wang, Z. (2017). Norms of valence, arousal, concreteness, familiarity, imageability, and context availability for 1,100 Chinese words. *Behavior Research Methods*, *49*, 1374–1385. https://doi.org/10.3758/s13428-016-0793-2

Yik, M. (2007). Culture, gender, and the bipolarity of momentary affect. *Cognition and Emotion*, *21*(3), 664–680. https://doi.org/10.1080/02699930600823702

Yik, M., Russell, J. A., Ahn, C.-K., Fernandez-Dols, J. M., & Suzuki, N. (2002). Relating the Five-Factor Model of personality to a circumplex model of affect: A five language study. In R. R. McCrae & J. Allik (Eds.), *The Five-Factor Model of personality across cultures* (pp. 79–104). Springer. https://doi.org/10.1007/978-1-4615-0763-5_5

Yik, M., Russell, J. A., & Barrett, L. F. (1999). Structure of self-reported current affect: Integration and beyond. *Journal of Personality and Social Psychology*, *77*(3), 600–619. https://doi.org/10.1037/0022-3514.77.3.600

Yik, M., Russell, J. A., & Steiger, J. H. (2011). A 12-point circumplex structure of core affect. *Emotion*, *11*(4), 705–731. https://doi.org/10.1037/a0023980

Received June 2, 2021
Revision received December 30, 2021
Accepted January 18, 2022 ■