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Arousal May Not Be Anything to Get Excited About

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Abstract

The idea of arousal as a non-specific state of activation has been implicated as an explanatory factor for many aspects of human behavior, ranging from emotional experiences to learning and memory. Critiques of this concept have highlighted that arousal is ambiguous and evidence for its role in emotion is mixed. However, contemporary emotion theories and empirical research continue to incorporate the concept of arousal in ways that fail to address its problems. Here, we review the origins of the term arousal in physiology and trace how it has been translated and applied to psychology (particularly as it relates to emotion). We consider whether the construct of arousal is currently (a) consistent and (b) useful in understanding human behavior.

Keywords
arousal, affect, emotion

The term arousal is pervasive in emotion research. Searching the terms "emotion" and "arousal" in Google Scholar identifies nearly a half-million hits. These results indicate that arousal is treated as a basic and well-established aspect of emotion including emotion experience (Russell, 2017), emotion recognition/perception (Petrolini & Viola, 2020; Sutherland & Mather, 2018), emotion regulation (Gross, 1998; McNaughton & Corr, 2009), emotion recall and memory (Kuhlmann et al., 2005; Schwabe et al., 2010), and emotion understanding (Cuve et al., 2018; Woodard et al., 2021). Yet, there is a striking lack of consistency and clarity about what the term arousal means and how it is measured. Despite this conceptual vagueness, the idea that arousal is a core component of emotion is often treated as axiomatic—an assumption taken as an unquestionable truth. Although axioms are meant to serve as starting points for further reasoning and exploration, many conceptualizations of emotion view arousal as so inherent that there is no need to question the supposition. For this reason, much current research on the topic is confirmatory: seeking to determine how or where, rather than if, arousal fits into explanatory models of emotion. Here, we consider whether the construct of arousal is (a) consistent and (b) useful in understanding human emotions.

Arousal has long been regarded as constituting emotion. Dating back to William James (1884) and Walter Cannon (1927), theorists have disagreed about the structure of emotion. These debates traditionally focused on whether emotions consist of discrete experiences characterized by specific psychological and physiological patterns (Ekman, 1992; Izard, 2007; Panksepp, 2005), or constructed categories resulting from interpretations of diffuse, nonspecific reactions to the environment (Barrett & Bliss-Moreau, 2009; Hoemann & Feldman Barrett, 2019; Lutz, 1988; Russell, 2017). Common to many of these theories has been the idea that instances of emotion can be described using a

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variety of features, one of which is affect. In the psychological sciences, affect refers to an aspect of experience that is not specific to any particular instance or type of emotion and is construed in terms of two continuous dimensions. The first is valence, a range from pleasantness or unpleasantness. The second is arousal, a range from activation to quiescence. Thus, arousal is meant to capture a non-specific energizing or activating state. Of note, both valence and arousal have been conceptualized and defined in varying ways across disciplines, including the humanities and other social sciences, where there are extensive and complex literatures on affect in which it is understood quite differently (Colombetti & Kuppens, 2024).

Viewed in the abstract, the notion of arousal certainly has intuitive appeal. However, empirical studies of arousal have used such a wide variety of operational definitions, conceptual formulations, and approaches to measurement that the actual role of arousal in emotion behavior is muddled. Multiple theorists have critiqued arousal, highlighting both the lack of definitional and measurement clarity around the construct (Blascovich, 1992; R. E. Thayer, 1978) and a lack of consistent evidence for a link between arousal and behavior regardless of how it is measured (R. Neiss, 1988; Silvia, 2005). Yet despite these critiques, the term continues to be evoked in current emotion theories without addressing these continuing problems. Here, we build on these prior critiques, highlighting how despite continued ambiguity around the term and lack of consistency in current evidence for its role in emotional responding, the use of the construct arousal remains largely unchanged—a stagnancy that has hindered progress in furthering our understanding of emotion across subfields. We begin by briefly outlining the history of arousal as a construct in physiology, and how this term has been translated to affective science. We then evaluate whether current evidence supports a consistent role of arousal in emotion and examine the utility of this construct in furthering understanding of emotion and behavior. Our conclusion points to ways the field might productively move forward.

Origins of the Term Arousal

The term arousal originated in the early twentieth century as an explanatory variable thought to play a role in facilitating learning and instinctive behaviors. In this early research, arousal was conceptualized as a non-specific energizing or activating organismic state (Duffy, 1934, 1957; Freeman, 1948). Key to this definition was the idea that arousal is *non-specific*, resulting in generalized activation across both central and peripheral physiological systems that corresponds with changes in behaviors. In this conceptualization, when an organism experiences a state of arousal it should produce parallel activation across peripheral systems, neural systems, behavioral states, and psychological experiences.

This theory about arousal arose from developments in two areas of psychophysiological research. The first area of research encompassed stimulation, lesion, and recording studies that examined the functioning of the reticular brainstem formation. These early studies led scientists to conclude that the reticular formation represented a relatively undifferentiated set of neurons that exerted non-specific activational effects diffusely throughout the cortex and periphery (Magoun, 1952; Routtenberg, 1968). These data resulted in the construct of an ascending reticular activating system, which was thought to regulate states of arousal in cortical and neurobehavioral systems (Moruzzi & Magoun, 1949; R. E. Thayer, 1978).

A second scientific development was an increased understanding of the autonomic nervous system (ANS). Initial studies suggested that the two branches of the ANS, the sympathetic and parasympathetic nervous systems, acted reciprocally to produce states of activation along an arousal continuum (Gaskell, 1916; Langley, 1921). Specifically, sympathetic nervous system (SNS) activation paired with parasympathetic nervous system (PNS) deactivation was linked to states of high activation and energetic demand (mobilization), whereas PNS activation paired with SNS deactivation facilitated states of low activation and energy conservation (calm and quiescence) (Carpenter, 1915; Jänig & McLachlan, 1992). Together, these data were taken as evidence for peripheral and central mechanisms that facilitated behavioral and physiological states along an arousal continuum that ranged from low activation/energy (sleep/calm) to high activation/energy (high wakefulness).

However, as neuroimaging and neurophysiological techniques have advanced, the data no longer support the long-held model of general arousal. The preponderance of evidence suggests that activation patterns in peripheral, central, and behavioral systems are differentiated and specific to environmental demands. Indeed, the reticular brainstem, thought to be critical to states of arousal due to its undifferentiated nature, is no longer viewed as an undifferentiated set of neurons with generalized, non-specific activational effects. Rather, the structure exhibits extensive differentiation, with multiple distinct ascending systems (Horn et al., 2020; Johnson & Anderson, 1990; Watson et al., 2017). Each of these systems produces differential patterns of afferent input to the central nervous system (CNS), dependent on environmental and interoceptive inputs, and have distinct neurochemical mediators (Krout et al., 2002; Paxinos et al., 2012; Sarter et al., 2003).

Moreover, other tenets of the early construct of arousal no longer hold. Measures of peripheral activation do not reliably covary with each other. For example, commonly used measures of arousal, like heart rate and electrodermal activity (EDA), do not reliably correlate with each other or with behavioral states (de Looff et al., 2019; Lacey et al., 1953; Lacey & Lacey, 1974). The ANS is no longer viewed as a system which results in a unidimensional arousal continuum

Table 1. A sampling of how arousal has been defined and operationalized across papers.

Construct	Measure	Definition used by the author	Citation
Activation	Latent variable based on observation/ theory	"Activating–Deactivating"	Nook et al. (2017, p. 884)
	Latent variable based on observation/ theory	"Arousal (activation)"	Bliss-Moreau et al. (2020, p. 993)
	Theoretical/review paper	"Arousal (sleepy–activation)"; "activation–deactivation (arousal or energy)"	Russell (2003, p. 147)
	Latent variable based on observation/ theory	"Arousal (bodily activation)"; "Arousal is a subjective state of feeling activated or deactivated."	Barrett (1998, p. 579; 580)
Arousal	Likert scale	No formal definition	Sutherland and Mather (2018)
	Likert scale, fMRI	"Arousal, which refers to a sense of energy or excitation"	Haj-Ali et al. (2020, p. 1)
	Mixture of Likert-type ratings and theoretical (certain words being low/ high arousal)	"Arousal (ranging from feeling quiet to active)"	Kuppens et al. (2013, p. 917)
	EDA	"Arousal is a general behavioral state characterized by sensory alertness, motor activity and emotional reactivity and produced by arousal electrophysiologic pathways of the nervous system"	Bortoletto et al. (2011, p. 372)
Energy	Ecological Momentary Assessment (EMA) with Likert-type ratings	"Arousal (e.g., feeling energetic)"	Maher et al. (2019a, p. 153)
Excitement	Likert scale	"The dimension of arousal captures low to high activity or engagement."	Woodard et al. (2021, p. e237)
	IAPs ratings, fMRI	No formal definition	Baucom et al. (2012)
	IAPs ratings, Likert scale, EDA activity	"Arousal (e.g., feelings of stimulation, excitation, arousal)"	Kron et al. (2015, p. 35)
Physiological arousal	Heart rate; EDA; Cortisol	No formal definition	Diemer et al. (2016)
	Heart rate; EDA	No formal definition	Herman et al. (2021)
	Salivary alpha-amylase (sAA)	No formal definition	Segal et al. (2012)
	Systole period	No formal definition	Rae et al. (2018)
	Pre-ejection period (PEP)	No formal definition	Quas et al. (2012)

from calm to activated (Berntson et al., 2012; Koenig, 2020; Porges, 2011; Smith et al., 2017). And although components of the ANS sometimes act in a reciprocal manner (SNS activation paired with PNS deactivation or vice versa), the ANS as a whole can also act in other ways, such as via co-activation and co-deactivation of the two systems (Cacioppo & Berntson, 2009; Weissman & Mendes, 2021). Taken together, this body of research suggested limited utility for the construct of arousal in explaining psychophysiological processes. Thus, the field of psychophysiology shifted away from arousal per se and towards understanding how complex patterns of physiological reactivity contribute to and are influenced by psychological processes (Cacioppo et al., 2000; Park et al., 2021; Seery, 2011).

Arousal and Emotion

Despite the lack of compelling evidence for a physiological state of generalized activation, the construct of arousal continues to be widely employed across the field of emotion research. A generalized state of physiological arousal was critical to early emotion theories; Schachter and Singer (1962, p. 394) concluded "… the evidence is good that the state of physiological arousal is a necessary component for emotion experience." Current models of emotion have incorporated the lack of evidence for generalized physiological activation, no longer positing a state of physiological arousal; instead, contemporary models of emotion now tend to evoke arousal as a state of experienced subjective activation. In this view, arousal is believed to occur during emotional experiences and, as a psychological experience, may or may not coincide with physiological or behavioral changes. Such a subjective state of general activation is evoked as an explanatory factor that accounts for how emotions are experienced (Hamann, 2012; K. A. Lindquist, 2013; Norman et al., 2014).

This experiential notion of arousal is purportedly measured through autonomic indices (Bortoletto et al., 2011; Collet et al., 2005; Greco et al., 2017), subjective ratings (Burriss et al., 2007; Gavazzeni et al., 2008; Šolcová & Lačev, 2017), and electroencephalogram (EEG) oscillations (Compton et al., 2022; Halász et al., 2004; Tian et al.,

2021). Although these methods yield very different kinds of data, all have been interpreted similarly as indices of subjective arousal (see e.g., Table 1). Below, we review whether there is consistent evidence for such an organizing role of arousal in emotion experience. Central to addressing this question are the vastly different ways that arousal and arousal-related constructs have been defined, labeled, operationalized, and measured.

Is Arousal an Independent Dimension of Emotion Experience?

Many current emotion theories posit a foundational role for arousal (K. Lindquist et al., 2012; Petrolini & Viola, 2020). This view came to prominence through James Russell's (Russell, 2003; for early perspectives see Wundt, 1904) circumplex model of affect, which proposed that affective feeling states are characterized by a blend of the two distinct dimensions of valence (ranging from pleasure to displeasure) and arousal (ranging from sleepy to activated). These affective feeling states are one underlying component of emotional states (e.g., the notion of "core affect," Russell, 2003). In general, affective scientists have used two different approaches to operationalizing or mustering evidence for arousal. In one, researchers measure participants' subjective reports of arousal and/or their physiological reactivity to the stimulus items. Then they examine whether the subjective ratings or physiological measures predict behavior (Baucom et al., 2012; Russell, 1980; Woodard et al., 2021). In the second approach, researchers simply presuppose (based on theory or previous data) that exposure to certain stimuli should result in high or low psychological states of arousal. For example, a picture of a gun pointed at someone should make people feel highly aroused, whereas a scene of a garden or forest should be calming. The researchers then assess whether research participants behave in ways consistent with the researchers' presuppositions about the stimuli (Bimler & Kirkland, 2001; Bliss-Moreau et al., 2020; Nook et al., 2017).

One commonly measured behavior is how individuals sort emotional stimuli (words, faces, and images) based on similarity. Both approaches to operationalizing arousal often use this type of task and result in data that are interpreted in terms of a two-dimensional structure underlying how individuals sort or categorize emotions. Researchers often assume that this two-dimensional structure reflects valence versus arousal, yet there is not consistent evidence that the dimensions that often emerge from emotion studies do, in fact, represent valence and arousal. The problem is that claims of data supporting a role for arousal in predicting behavior are merely an interpretation or speculation about those data. Such reasoning can be circular, reifying the construct rather than testing it. For example, studies that rely upon researcher presuppositions about whether particular stimuli ought to generate high or low arousal (as well as positive or negative valence) tend to conclude that participants' behavior maps onto the dimensions of valence and arousal (Bimler & Kirkland, 2001; Bliss-Moreau et al., 2020; Nook et al., 2017). In contrast, more mixed evidence results from studies utilizing participants' reports of arousal and valence, rather than relying on researcher interpretations. Some research suggests these subjective ratings do account for differences in participants' behavior (Kuppens et al., 2013; Russell, 1980), while others find little contribution (P. J. Maher et al., 2019b; Woodard et al., 2021). Similarly, in studies utilizing physiological indices of arousal in response to stimuli, some report evidence for arousal as independent from valence (Berntson et al., 2007; Gavazzeni et al., 2008; Lang et al., 1993)—although this evidence is subject to several important caveats, including use of normative arousal ratings rather than individual level ratings (Gavazzeni et al., 2008) and effects of arousal only for positive but not negatively valenced stimuli (Berntson et al., 2007)—and others suggest that arousal covaries with valence (Kron et al., 2015; Šolcová & Lačev, 2017; Winton et al., 1984).

Even in studies that find support for a two-dimensional structure, arousal often contributes less than valence in explaining behaviors and is subject to more variability dependent on participant characteristics and task demands (Stanisławski et al., 2021; Terracciano et al., 2003). For example, individuals rely less on arousal when rating their own mood states as compared to rating the semantic similarity of emotion words (Feldman, 1995). Finally, and perhaps most importantly, there are data suggesting that individual's emotional responses may be better explained by three or four-dimensions (Shaver et al., 1987; Stanley & Meyer, 2009); beyond valence and arousal, dimensions including dominance, intensity, predictability, and potency may all play a critical role in this regard (Fontaine et al., 2007; Jerram et al., 2014; Laukka et al., 2005; Putkinen et al., 2020; Remington et al., 2000). These data suggest that a two-dimensional model may not best capture emotion experiences. Additionally, they point to a need for further examination of how other dimensions beyond arousal and valence contribute to emotional responses. Taken together, these inconsistencies raise questions about whether arousal is a distinct dimension of emotion experience and if it is meaningful in terms of understanding behavior.

Why Are the Data About Arousal and Emotion So Inconsistent?

There are at least three reasons why data on arousal are not consistently related to individuals' performance in emotion tasks. These include the confounding of experience and perception, varying definitions of arousal, and invalid assumptions about the relationship between the constructs of arousal and valence.

Confounding of Stimulus Perception With Individual Experience. One problem is that there are critical differences

between whether participants are asked to rate their own experiences of arousal in response to a stimulus ("How does seeing this make you feel?") versus being asked to rate or evaluate how another individual might respond to a stimulus, or even a more disengaged rating of a stimulus' general arousal ("Please rate this image on a scale of low to high"). The former is an individual focused approach, while the latter is focused on the stimulus itself. Many theories of emotion posit that valence and arousal only explain how an individual experiences an emotion, not necessarily how they perceive emotional content in stimuli (see Russell, 2017 distinctions between "Core Affect" and "perceptions of affective quality"; see also Itkes & Kron, 2019 for review). While this distinction between experience and perception may (or may not) be valid, it renders reliance on ratings or judgments of external stimuli—even if the ratings are phrased in a way aimed at capturing an individual's emotional experience rather than their perception of the stimulus—difficult to interpret (Kuppens & Verduyn, 2017). This distinction has the potential to create further confusion when stimuli from one study are used differently in another study. For example, one study might have participants rate the stimuli, not their experiences elicited by the stimuli (e.g., Tottenham et al., 2009). But then a subsequent researcher uses these same stimuli, and the rating data from the earlier study, to design a study aimed at inducing high or low arousal states in participants (e.g., Alpers et al., 2011; Fisher et al., 2015). However, this would be under the mistaken assumption that there is evidence for these stimuli being triggers of arousal.

This issue is deeper than being simply about what research participants are asked to do when rating arousal. Regardless of whether a study is taking an individual-centered or a stimulus-centered approach, participants are being asked to separate their own experience from how they perceive a stimulus. Evidence indicates that it is difficult (and may not even be possible) to disentangle one's own affective experience from one's perceptions. How an individual perceives, and thus rates, stimuli will depend upon their current affective state; similarly, an individual's affective state will be influenced by how they perceive stimuli in their environment. For example, individuals judge faces as more happy when they report being happy (Trilla et al., 2021). Additionally, a person's current physiological state changes how they rate stimuli (Garfinkel et al., 2014, 2020; Garfinkel & Critchley, 2016), as well as how they attend to and remember emotion stimuli (Azevedo et al., 2018; Kimura, 2019; Pfeifer et al., 2017). This interdependency between emotion experience and emotion perception raises critical issues. Ratings from one individual at one time may not relate to how that same individual might rate a stimulus at another time, how another person in the same study might evaluate the stimuli, or how individuals in a separate study might respond to it.

Table 2. Correlations of valence and arousal ratings for emotion words across multiple affective lexicons.

		Arousal			Valence		
		Study 1	Study 2	Study 3	Study 1	Study 2	Study 3
Arousal	Study 1	*NA*	–	–	–	–	–
	Study 2	0.45	*NA*	–	–	–	–
	Study 3	0.36	0.61	*NA*	–	–	–
Valence	Study 1	−0.33	−0.08	0.22	*NA*	–	–
	Study 2	−0.36	−0.10	0.05	0.93	*NA*	–
	Study 3	−0.32	−0.09	0.08	0.96	0.94	*NA*

Note. Examining correlations across valence (measured on a continuum from negative to positive) and arousal ratings of words from three different studies (Study 1: Clark & Paivio, 2004; Study 2: Mohammad, 2018; Study 3: Warriner et al., 2013) finds valence ratings across samples are reliably and highly correlated ($r > .90$). In contrast, arousal ratings demonstrate greater variability in the strength of their association across studies (ranging from $r = .36$ to $r = .61$) and in their relation to valence ratings (ranging from $r = -0.36$ to $r = 0.22$) suggesting less consistency in how arousal words are rated across samples. All data and analyses for this table can be found on OSF (https://osf.io/w4ydj/).

Inconsistent Definitions of What Constitutes Arousal. A second factor that contributes to the inconsistency of data about arousal is that the concept is defined and operationalized in manifold ways, with strikingly little overlap across studies. As a concrete example, many different kinds of labels are used across studies for the seemingly straightforward task of asking research participants to evaluate their own arousal. These words include excitement (Kron et al., 2015), arousal (Berntson et al., 2007; Haj-Ali et al., 2020), activation (Kuppens et al., 2013), energy (Kron et al., 2015; P. J. Maher et al., 2019b), and intensity (Bradley et al., 2001), to name a few. Each of these words conveys different meanings and may elicit differing interpretations among research participants. Not surprisingly, arousal ratings for emotion words are only modestly correlated across studies (Grühn, 2016). Our own analysis comparing multiple affective ratings of lexicons, shown in Table 2, similarly finds only modest correlations for arousal ratings of emotion words. This raises the possibility that the so-called arousal ratings across different studies may not be indexing the same construct.

This issue of construct validity is not limited to rating emotion words. Similar concerns arise when very different methods, such as peripheral physiological activation, are used as measures of arousal. The use of physiological measures, particularly electrodermal activity (EDA), rests on the assumption that these indices covary with subjective states of arousal while individuals view emotionally evocative stimuli (Greenwald et al., 1989; Lang et al., 1993). But this may not be a valid assumption. There are some reports that EDA and subjective arousal ratings correlate with each

other (Kron et al., 2013, 2015; Lang et al., 1993). However, other evidence suggests either a minimal direct relationship between these measures or a much more complex relationship that is dependent upon other individual difference factors (Burriss et al., 2007; M. B. Neiss et al., 2009; Šolcová & Lačev, 2017). Even among those studies that conclude that there is a relationship between EDA and subjective arousal ratings, the strength of this relationship varies greatly. At most, only half of the participants in these studies demonstrate a strong link between EDA and reported arousal (Cacioppo et al., 1992; Greenwald et al., 1989; Kron et al., 2013; Vico et al., 2010). This variability is not surprising because EDA is influenced by many psychological processes. For this reason, a one-to-one mapping of EDA with any psychological process is unlikely (Cacioppo et al., 2009; Dawson et al., 2000).

Faulty or Inconsistent Conceptual Framing of Affective Dimensions. A third possibility is that when researchers attempt to assess arousal, they are not capturing arousal at all. Instead, they may be measuring an aspect of valence. Although it has become common to consider valence and arousal as independent dimensions of emotion, there is some evidence that these are similar constructs. For example, some studies find that arousal and valence demonstrate a linear or V-shaped relationship (Brainerd, 2018; Kuppens et al., 2013; Mattek et al., 2017, 2020), suggestive of an interdependency between the constructs. Additionally, many of the studies examining dimensions of arousal and valence utilize bipolar rating measures of valence—where participants are asked to rate the valence of the stimuli along a single continuum from positive to negative (Figure 1A) (Kuppens et al., 2013; Mattek et al., 2017). However, when a bivariate rating scheme (Figure 1B) is used, in which individuals are asked to rate positivity and negativity separately, arousal is correlated with, rather than independent from, positivity and negativity ratings (Itkes & Kron, 2019; Kron et al., 2013). Additionally, models that focus on the co-variation between positive and negative affect rather than arousal and valence find this co-variation is linked to both behavioral and neural affective responding (Grabenhorst et al., 2007; Larsen et al., 2004; Norris & Larsen, 2020). These data raise the possibility that arousal reflects covariation in experiences of positivity and negativity (Woodard et al., 2021). More research is necessary to determine whether arousal is indeed a distinct dimension from valence or if it is indexing an aspect of valence such as intensity or covariation in bivariate valence.

Is Arousal a Useful Construct in Explaining Emotion?

Even if the issues described above regarding inconsistencies in the measurement of and data about arousal were resolved, there remains the question of whether arousal is a useful construct for understanding emotion. Because of its simplicity, the notion of arousal seems intuitive and appealing, and it has become engrained and reified in our folk beliefs about emotion. However, it is not clear whether the idea of an arousal component to emotion has advanced our understanding of emotion (R. Neiss, 1988; Silvia, 2005; R. E. Thayer, 1978). For this reason, it is useful to reflect upon whether and how arousal guides predictions or hypotheses about behavior, as well as the extent to which it informs a useful taxonomy of labels for different feeling states or instances of emotions.

The primary challenge in addressing these questions is that there is no parsimonious definition that accounts for all the ways arousal is deployed to explain a wide variety of data. As we noted earlier, the argument that arousal is best conceived of as a unitary conceptual dimension is longstanding. Over time, that definition has transformed into versions in which arousal is (a) a hypothetical construct, (b) a subjective/psychological phenomenon, or (c) an abstraction representing processes ranging from being wakeful to feeling impassioned to exerting effort. At the same time, it is now apparent that arousal is not synonymous with any one measure or descriptor; no single physiological, behavioral, or self-report index is a necessary or sufficient determinant of the construct. For these reasons, arousal may not be useful because it is treated in a way that glosses over the potentially important mechanistic differences that many research initiatives are seeking to explain.

Part of the problem is that arousal is intended to encapsulate what are likely disparate features that are all central to understanding affective states and emotions. For example, one aspect of arousal is thought to be the perception of internal bodily sensations (Barrett et al., 2016; Critchley & Garfinkel, 2017). This is more of a biological, mechanistic component of arousal. Much like experiences of loudness reflect the vibrations of air particles in the ear, or brightness is caused by the number of photons entering the eye, the internal sensations ascribed to psychological arousal are often understood as a part of consciousness that reflect a functioning nervous system. However, this essentialist view only accounts for a part of how these phenomena are possibly linked to feelings. Internal sensations also reflect social constructions, language, and values—the things that we care about, our incentives. Indeed, most accounts of arousal (and valence) fuse together sensory states and mental activities, including labels such as sleep/sleepiness, boredom, alertness, and passion/engagement. The question is whether a truly meaningful hypothesis can be formulated around a construct that reflects ambiguity about sensations, perceptions, states of consciousness, and social/interpersonal values. It remains to be seen if these states of being are compatible and heuristically useful as a single construct.

Whatever it might be, arousal is multifaceted rather than a pure entity. Perspectives that assume the existence of arousal rely upon the idea that arousal is an emergent subjective

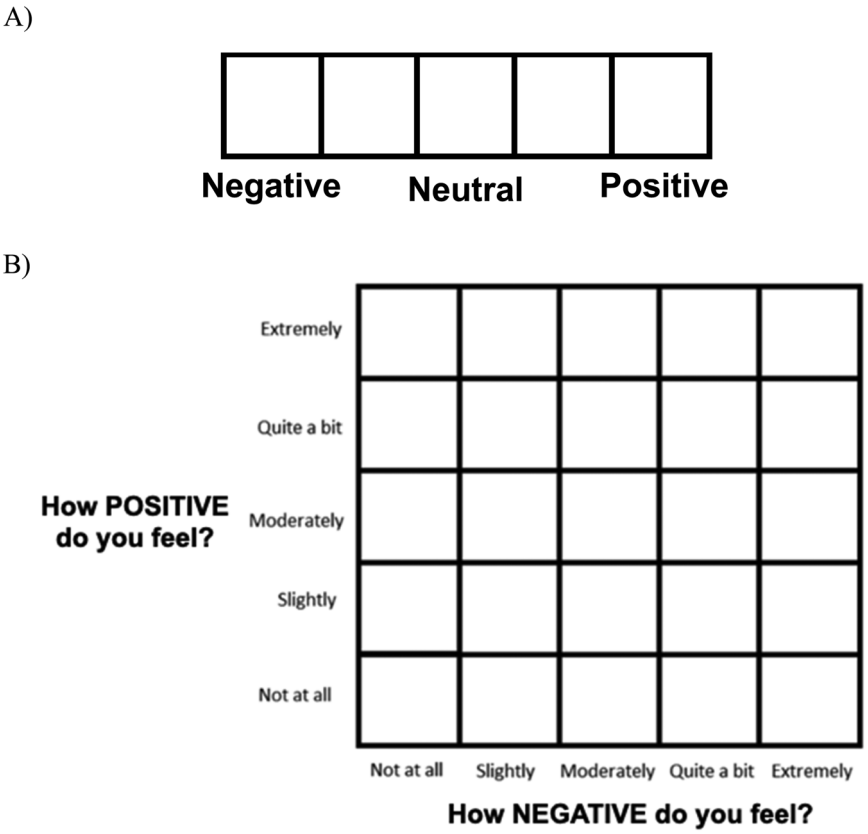

Figure 1. Bipolar (A) and bivariate (B) ratings scales for valence.

phenomenon that is not dependent on any particular physiological or behavioral state (Kuppens et al., 2013; K. A. Lindquist, 2013; Russell, 2003). This conceptualization was necessary to account for the overwhelming lack of evidence for a physiological or behavioral state of generalized activation. However, it leads to the question of whether a construct that requires increased ambiguity has utility. Lacking in precision, it is difficult to envision a way in which specific hypotheses across a broad array of behavioral domains could be predicated upon arousal, or how claims based upon the construct of arousal could be falsified.

It is also not clear that any psychological or behavioral effect can be unambiguously interpreted in terms of arousal. An example of a widely known explanatory model evoking arousal is the so-called inverted-U effect of the relationship between anxiety and performance (Anderson, 1990; Baldi & Bucherelli, 2005). As the story is often told, arousal levels that are too low or too high results in poor performance, whereas moderate arousal leads to optimal performance. But how certain can we be about what process is driving this effect? Rather than arousal, it is possible that an individual's level of effort or perceived exertion may best account for behavioral performance and, possibly, an individual's subjective feelings of anxiety (Humphreys & Revelle, 1984; Jarvis et al., 2022; Pribram & McGuinness, 1975; Westbrook et al., 2013). Indeed, the original research in which this principle is grounded never claimed to be indexing arousal, but rather described differences in learning dependent on stimulus shock intensities (Yerkes & Dodson, 1908). Thus, appeals to arousal as underlying causes for behaviors or instances of emotion are inferences drawn from indirect indexes. In this regard, reliance on arousal as an explanatory construct may obscure other dimensions of emotion with more revelatory power (Laukka et al., 2005; Putkinen et al., 2020; Schmidtke et al., 2014; Warriner et al., 2013; Woodard et al., 2021).

Finally, we can ask whether the concept of arousal has helped clarify or refine theories of emotion. Arousal was initially defined as the "intensity of [a] reaction" in an organism (Duffy, 1934). Some models of emotion continue to characterize intensity and arousal as one and the same (Bradley et al., 2001; Haj-Ali et al., 2020; Mattek et al., 2017), whereas others treat intensity and arousal as distinct components of affective experiences (Barrett & Russell, 1999; Petrolini & Viola, 2020). The extent to which intensity and arousal are similar facets of emotion remains unclear (Kuppens et al., 2013; Putkinen et al., 2020), and begs the question of the ontological status of emotions. Despite this, intensity is construed as a premise that assumes some truth

about the nature of emotion. However, how intensity and arousal are defined and operationalized should be grounded in scientific evidence.

Consider the English language category *anger*. One view holds that arousal is the affective equivalent of turning up or down the volume while listening to music (Lang et al., 1992; Laukka et al., 2005). Someone experiences some displeasure. But with a little more arousal, that experience turns to irritation. Unchecked, the increasing arousal turns to annoyance, with more arousal that annoyance becomes maddening, and with increasing arousal, that experience can escalate to rage. Notice that the implicit assumption of this account is that there is some coherent supraordinate emotion category, within which an individual can experience a variety of levels of intensity of that emotion. Arousal (or intensity) here accounts for variation, but that variation still reifies a category of emotion (in this case *anger*).

Yet an equally plausible view is that emotions do not exist as a finite set of broad categories. In this view, there is no within-category variation based upon arousal or valence. Instead, experiences of displeasure, annoyance, and rage are not levels of anger, but distinct entities. The point here is that evoking arousal assumes a relationship between feeling states that co-varies along the dimensions of arousal, valence, and possibly other dimensions. But such a relationship remains an assumption that, if incorrect, may hide other ways in which to observe and conceptualize emotions that are similar across individuals.

Alternatives to Arousal

There are theoretical perspectives on affect and motivation that avoid reliance on arousal, instead focusing on how context and variability in perceptions of events can shape the specificity of physiological responses (Berntson & Cacioppo, 2015; Blascovich, 2008; Norman et al., 2011; Seery, 2011). These approaches have been able to make reliable predictions about people's behavior. As examples, these frameworks explain why individuals demonstrate distinct cardiovascular responses to similar types of potential threats—differences in reactivity are driven by differences in how an individual perceives the threat. Individuals who perceive their personal resources as sufficient to outweigh a situational demand have increased sympathetic activation accompanied by increased cardiac output and decreased vascular resistance. In contrast, individuals who perceive the same situation as outweighing their personal resources still demonstrate increased sympathetic activation, but it is accompanied by decreased cardiac efficiency including minimal change in cardiac output and increased vascular resistance (Mendes & Park, 2014; Quigley et al., 2002; Sammy et al., 2017). These differing cardiac responses are linked to behavioral outcomes that include academic and athletic performance (Blascovich et al., 2004; Seery et al., 2010). Reliance on generalized activation is insufficient to capture these effects.

Conclusion

Scientific ideas that are intuitive and easy to understand are often widely adopted. However, prioritizing simplicity can sometimes come at the cost of ignoring complexities that are essential for understanding a phenomenon. Arousal is a construct that feels intuitive and simple but lacks consistent evidence for its role in emotion and is often employed in vague and inconsistent ways. These inconsistencies raise questions about the validity of arousal as a construct. Determining whether arousal has utility as a dimension of emotion experience requires greater clarity. What is the distinction between ideas such as intensity and activation? Are there clear and consistent conceptualizations for psychophysiological measures such as EDA? Employing this greater specificity allows for more nuanced and empirically tractable investigations of the features that contribute to emotion experiences.

We have described arousal as a construct that lacks clarity and usefulness. Ideally, researchers would abandon the use of the term arousal completely. However, we are resigned to a more realistic view: that arousal is now so ingrained in the history of emotion research many researchers will still rely upon it. Our view is based upon the fact that the arousal construct has been eloquently critiqued numerous times (R. Neiss, 1988; Silvia, 2005; R. E. Thayer, 1978), yet researchers have been reluctant to abandon it. The term

Table 3. Defining constructs for common measures of "arousal."

Measure or Approach	Interpretation
Self-reports of perceived intensity	Subjective sense of quantity or amount of experience (i.e., a little angry, very angry, or anywhere in between).
Self-reports of perceived activation	Subjective sense of levels of psychological, behavioral, and physiological reactivity. Can range from minimal (often associated with sleep) to high.
Self-reports of perceived feelings of energy	Subjective sense of amount of resources available to exert mental or physical effort.
Electrodermal activity; pre-ejection period; sAA/epinephrine	Motivated responding as indexed by sympathetic nervous system activation.
heart rate	Motivated responding as indexed by autonomic nervous system activation.
Systole period	Motivated responding as indexed by baroreceptor activation

persists in its use across the fields subsumed within affective science without acknowledgment or rectification of the historical problems inherent in the construct. For this reason, we offer recommendations that are more likely to be implemented: (a) encouraging researchers to provide further clarity into whether arousal is a useful construct in understanding emotion experience specific to each study in which it is evoked, and (b) detailing how arousal is measured and defined in each study.

We suspect part of the reason arousal has such staying power is because valence alone is insufficient to explain emotion experiences. At first glance, a construct like arousal appears to provide a parsimonious explanation for problems such as how to differentiate emotion categories such as excitement from relaxation or sadness from boredom, or why a negative affective state like anxiety is more easily reappraised as excited than calm (Brooks, 2014; Clore et al., 2018; Jamieson et al., 2018). As we have argued here, we agree that factors beyond valence are necessary to distinguish emotions. But it is not clear from the empirical evidence that arousal is a critical factor, or how many additional dimensions beyond valence may be needed. To this end, we suggest that researchers treat arousal as a construct requiring further evidence rather than a verified fundamental property. This requires moving away from approaches in which researchers make inferences about whether identified dimensions of behavior fall along those of valence and arousal based on their own presuppositions about what represents a high or low arousal state (or positive or negative valence). The data we have highlighted suggests there is not enough clarity around where different emotion states fall on an arousal continuum (if they do) to make these types of theoretically driven determinations. We first need to establish what arousal is and how it relates to emotion experiences and behaviors.

Taking this type of approach would also mean using greater precision in describing, defining, and interpreting what has been measured under the rubric of "arousal." Arousal represents an umbrella term that includes a multitude of concepts and measures. What constitutes arousal can differ depending on the researcher defining the term or the participant interpreting the term when being asked to rate stimuli. In Table 3, we offer suggestions for how to interpret the indices commonly subsumed under the term arousal. Employing this type of specificity in definitions and measures will allow for increased comparability across studies as well as a more concrete understanding of how each of these differs relates to emotion experiences. Examining how these different measures covary and relate to each other can further aid in this goal, allowing for a better understanding of how these different components contribute to emotion and behavior. While this introduces an additional level of complexity, this type of research is necessary to develop concrete predictions about how components of affective experience relate to behavior. Implementation of these suggestions has the potential to allow for more nuanced and fruitful investigations of what contributes to emotion experiences.

In many ways, the field of emotion research continues to rehash issues that originated in the nineteenth century. The fact that these discussions persist suggests a need for new approaches that challenge engrained beliefs about the role of arousal in emotion experiences. These types of new approaches are necessary to move beyond existing debates. Doing so will advance understanding of emotion by illuminating the mechanisms through which emotion processes facilitate engagement with the broader social world, opening opportunities for important new insights that can both expand basic science as well as motivate novel applications of emotion science to the spheres of health and education.

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