

COMMENTARY

Is “Arousal,” as a Scientific Concept, Worse than Useless?

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Abstract

This paper discusses (i) the usefulness and (ii) the clarity of the concept of arousal. In discussing its usefulness, I argue that we can explain some key “arousal effects” without relying on the concept of arousal. To do so, I consider the role of the appraisal of affective relevance as a process mainly subserved by the amygdala and explaining emotional effects on attention, memory, and learning. Then, with respect to the clarity of the concept of arousal, I use the componential approach to emotion to suggest that further research may investigate whether the umbrella term “arousal” covers five different concepts (energy, sympathetic nervous system activity, intensity, strength, and salience), each corresponding to a specific component of emotion.

Keywords

amygdala, appraisal, arousal, components of emotion

Duffy (1941) famously considered that “‘emotion,’ as a scientific concept, is worse than useless” (p. 283) and suggested that it should be replaced by the concept of “arousal” when it comes to scientific explanations of behavior (Johnston & Vitello, 2021). I have myself wondered for many years whether “arousal” may be a misleading concept, and therefore “worse than useless” for scientific purposes. Given the impressive increase of emotion research since the 1950s (see Dukes et al., 2021), it seems fair to conclude that emotion is in fact a useful concept for the sciences interested in the mind, the brain and behavior, and that Duffy’s call for replacing “emotion” with “arousal” did not convince the field. Are we now in a period in the development of the affective sciences when we should even renounce the concept of arousal? If so, (how) should we replace it?

In their thought-provoking article, Smith et al. (in press) consider in depth whether the construct of arousal is consistent and useful for understanding human emotions. They

conclude that “ideally, researchers would abandon use of the term arousal completely” (p. X). In this commentary, I join these authors, as well as others (e.g., Colombetti & Kuppens, 2024; Frijda, 1986; Neiss, 1988; Robbins, 1997; see Sander, 2013), in regretting the vagueness of the general term arousal, and I argue that an *unspecified* use of the term arousal should be abandoned. I also argue that there may be ways to avoid “throwing the baby out with the bathwater”: an appraisal-driven component-based conceptual clarification of arousal can help us keep what is interesting about arousal and abandon what is misleading. More specifically, I comment on two key issues raised by Smith et al. (in press): (i) the *usefulness* and (ii) the *clarity* of the concept of arousal. In discussing its *usefulness*, I argue that we can explain some key “arousal effects” *without* relying on the concept of arousal. To do so, I consider the role of the appraisal of *affective relevance* as a process mainly subserved by the amygdala and explaining emotional effects on attention, memory, and learning. Then, with respect to the *clarity* of the concept of arousal, I use the componential approach to emotion to suggest that further research may investigate whether the umbrella term “arousal” covers five different concepts (energy, sympathetic nervous system activity, intensity, strength, and salience), each corresponding to a specific component of emotion.

Before focusing on arousal, it is important to acknowledge that this is not the only construct that would benefit from conceptual clarification in the affective sciences. It is certainly wholesome to aim at further clarifying other concepts commonly used in affective sciences, such as valence, reward, pain, well-being, effort, feeling, emotional intelligence, empathy, stress, and, obviously, emotion. It is also worth noting that the concept of arousal is employed widely outside the affective sciences, notably in research on sleep/wakefulness, physical exercise, attention, performance,

memory, and personality (Sander, 2013). Accordingly, debates on arousal that take place in affective sciences may be relevant for these other research areas, and *vice versa*.

What is the function of arousal? In the affective sciences, arousal is typically used to describe aspects of the emotion response itself (e.g., felt energy or sympathetic nervous system activity), and to explain effects of emotion on cognition and behavior. The function of arousal can be analyzed within the framework of *affectivism*, which emphasizes that the inclusion of affective processes in models of behavior, mind, and brain “not only explains affective phenomena but, critically, further enhances the power to explain cognition and behavior” (Dukes et al., 2021, p. 816). Without repeating the analysis and conclusions provided by Smith et al. (in press), I would like to elaborate on their particularly enlightening section on “alternatives to arousal.” I suggest that we can explain several phenomena supposed to be arousal-related *without* using the concept of arousal. In particular, several arousal-related phenomena can be explained by *appraised concern-relevance* (also called *affective relevance*; see Sander, in press). I discuss below the idea that affective relevance—rather than arousal—can be taken into account in order to explain (i) the computational profile of the amygdala, (ii) emotional attention, (iii) emotional memory, and (iv) emotional learning.

With respect to (i), since the 1990s affective neuroscience has developed increasingly advanced methods and models for understanding the emotional brain (Hamann, 2024; Sander, in press). The brain system that has been studied the most with respect to emotion is arguably the amygdala. Over around three decades of research on the amygdala in humans, several works have questioned its specific function (Kragel et al., 2024). Among prevailing hypotheses concerning its role in emotion, the view that the amygdala represents arousal has been particularly influential (e.g., Costa et al., 2010; Hamann, 2003, 2012). An alternative account, however, is that the function of the amygdala is to appraise the relevance of stimuli for an individual given their current concerns such as goals, needs, and values (e.g., Murray et al., 2023; Sander et al., 2003).

As for (ii), it has been suggested that an affective variable explaining the privileged orientation of attention toward emotional stimuli is the dimension of arousal (Zsidó, 2024). However, an alternative account of emotional attention suggests that the reason why certain stimuli preferentially orient attention is that they are appraised as relevant for the individual’s current goals, needs, and values. For instance, a meta-analysis suggested that relevance was better than arousal for predicting the magnitude of the bias in emotional attention (Pool et al., 2016).

Third (point iii), arousal has also been suggested to represent a key dimension explaining episodic memory facilitation for emotional stimuli (Cahill & McGaugh, 1998). However, research testing the role of affective relevance in memory facilitation has also suggested that such

mechanisms may well explain the emotional effects on episodic memory without the need to rely on the dimension of arousal (Montagrin et al., 2013; Montagrin & Sander, 2016).

Finally (point iv), with respect to emotional learning (i.e., the process whereby initially neutral stimuli acquire affective value or a stimulus’s affective value is updated; Pool & Sander, 2021), the mechanism of affective relevance also seems to be a more appropriate explanation than the arousal dimension for enhanced Pavlovian aversive conditioning (Stussi et al., 2018, pp. 918–919).

In the affective sciences literature, it is not unusual to use the same key term to refer to different phenomena—as in the case of “valence” (Colombetti & Kuppens, 2024), and more generally of “emotion” and “feeling,” which are sometimes used interchangeably, and sometimes used to describe very different phenomena (Sander, 2013). Smith et al. (in press) make a convincing case that “arousal” is also a particularly unclear concept. In fact, “arousal” has been used to refer to various constructs or measures, such as *activation*, *alertness*, *bodily response*, *energy*, *excitement*, *intensity*, *reactivity*, *salience*, *strength*, *sympathetic nervous system activity*, or *tension*. This multiplicity can be misleading when the terms are wrongly used interchangeably, as if they were equivalent, thus creating a “conflation problem” (Colombetti & Kuppens, 2024, p. 604). An obvious way to avoid the conflation problem is to use specific terms instead of the general term “arousal” when referring to different phenomena. Frijda (1986, p. 168), for one, already distinguished three arousal response systems: autonomic arousal, electrocortical arousal, and behavioral activation. Other distinctions have been proposed. As advocated by Colombetti and Harrison (2019), a minimal distinction should be made between “experienced arousal” and “physiological arousal.” This distinction between two aspects of the emotion response is already very useful. Moreover, computational analyses of emotion typically decompose an emotion into functionally interacting systems (e.g., Sander & Koenig, 2002; Sander et al., 2005; see also Stussi & Sander, 2024). Here, I suggest that the componential approach to emotion may allow us to differentiate between five meanings of the term arousal as it is used in the literature on emotion. According to the componential approach (Figure 1, Pool & Sander, 2021), an event is appraised (elicitation) by the individual according to their current concerns, values, and goals (motivational processes displayed in orange). This elicitation process triggers an emotion response involving multiple other processes (displayed in red): autonomic physiology, action tendency, expression, and feeling. Together with the elicitation process, these processes involved in the emotion response form the “emotion components.” All emotion components interact among themselves, as well as with further cognitive processes (displayed in blue) such as attention, memory, learning, and decision-making.

Given this framework, we could posit four different meanings of “arousal,” related to the emotion response. More speculatively, we may even posit a fifth meaning, in relation

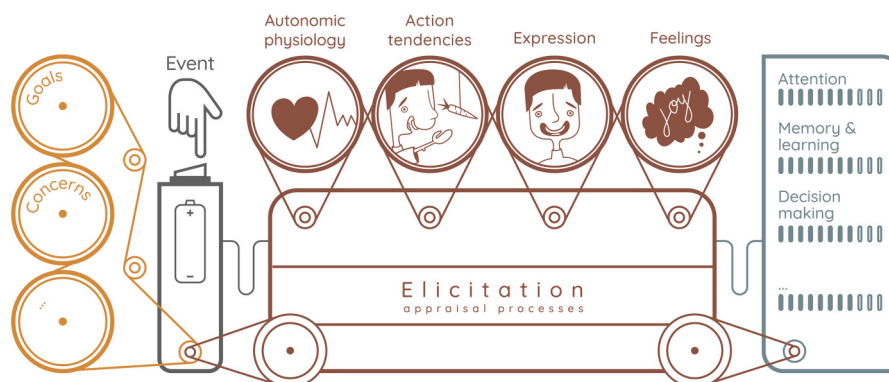


Figure 1. Illustration of the componential approach to emotion (from Pool & Sander, 2021).

to the elicitation process. Further conceptual analyses could investigate more deeply the distinction that we propose here as a first step. Concerning the emotion response, terms such as “activation,” “alertness,” “energy,” “excitement,” or “tension” often refer to the *feeling* component and are particularly used in models aimed at understanding the structure of conscious affective experience. Terms such as “bodily response,” “reactivity,” or “sympathetic nervous system activity” rather refer to the *autonomic physiology* component. The terms “intensity” and “strength” would rather easily be associated to the two other components of the emotion response: *expression* and *action tendencies*, respectively. Finally, even if arousal is typically considered an aspect of the emotion response, it has sometimes been related to processes that are typically involved in *emotion elicitation*. Earlier, I presented the concept of appraised concern-relevance (or affective relevance) as an interesting alternative to arousal in explaining phenomena that are supposed to be arousal-related. The construct of (motivational) “salience” has often been used to describe a mechanism that is conceptually close to “affective relevance” (Stussi et al., 2018). Although the suggestion that arousal is part of emotion elicitation seems conceptually difficult to defend, some researchers may consider such (motivational) salience as corresponding to the type of arousal involved in emotion elicitation; for instance, Costa et al. (2010) defined emotional arousal as the *salience* of a stimulus.

To conclude, I suggest that it is the *unspecific* use of the term arousal that is “worse than useless.” Such use can be misleading in two ways.

First, it can be functionally misleading because arousal is often used to explain some effects that may in fact be better explained otherwise. In that sense, there may be a *confound* with respect to some findings such as those discussed above concerning the amygdala, emotional attention, emotional memory, and emotional learning. Indeed, I argued above that some of these effects can be accounted for by the process of affective relevance rather than by arousal (in the sense of *energy* and in the sense of *sympathetic nervous system activity*).

Second, the unspecific use of the term arousal is misleading given the many ways it has been used over the century, and the multiplicity of concepts with which it has been associated (see also the commentary by Dror, this issue). However, there are several ways by which the meaning of the term can be specified: (i) it can obviously be explicitly defined by the author who is using it; (ii) its meaning can be so constrained by the framework that is using it so that it is not ambiguous. Indeed, when it comes to scientific concepts rather than lay terms, some of the responsibility for conceptual clarity is also on the side of the expert reader. For instance, when the reader comes across the term arousal in a paper using the *core affect* framework, the meaning of the term arousal is specified by the theory: in that case, it is much more likely that the term refers to “feeling energetic versus enervated” than to “displaying pupil dilation”; (iii) we may opt for specific terms when referring to the various meanings that the umbrella term arousal covers. In this respect, the term *salience* rather than arousal may be used when the author considers the emotion elicitation process. Although I would not personally equate affective relevance to arousal, some authors appear to use the term in this rather atypical way (e.g., Costa et al., 2010). For the emotion response components, the terms *sympathetic nervous system activity*, *intensity*, *strength*, and *energy* may be used when the author considers the autonomic physiology, the expression, the action tendencies, and the feeling components, respectively.

Ironically, maybe, the ambiguity of the term arousal is useful in at least one way: it pushes our field to think more deeply about the constitutive processes of emotion.


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