



AUTHOR RESPONSE

The Need for New Perspectives on Arousal in Emotion Theory

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We appreciate the interest and enthusiasm of the reviewers, editors, and commentors for the ideas articulated in “Arousal may not be anything to get excited about.” It is encouraging to see a convergence of thinking regarding these issues across different disciplines and perspectives. All three commentaries highlight additional areas of research that inform the issues raised in our original manuscript. Dror (in press) provides historical perspectives that help better contextualize why arousal represents a “fuzzy” construct lacking clarity, while Sander (in press) and Thayer and Friedman (in press) outline frameworks researchers can use to help clarify whether arousal is a useful construct in explaining emotion experiences. All three commentaries further discuss the difficulties associated with parsing the data on arousal because of inconsistent definitions and conceptual framings across and within subfields of affective science. While we land in slightly different places regarding the utility of arousal, areas of agreement are clearly greater than those of disagreement, with all indicating a need for increased specificity in how we employ and study the construct.

Our article is not the first to address the issue of ambiguity surrounding arousal—the commentators themselves, and others, have made similar arguments (Berntson & Cacioppo, 2009; Colombetti & Kuppens, 2024; Dror, 2014; Friedman & Thayer, 2024; Sander et al., 2018). We used an intentionally playful title precisely because arousal is still often a primary lens through which data are interpreted despite many scholars concurring that the construct is at best ambiguous and at worst a theoretical dead end. Nearly every contemporary theoretical account of emotion evokes arousal, in some form, as a core feature. Emotion researchers accept ambiguity about what, precisely, constitutes arousal. This is likely because, as discussed in the commentaries and our original manuscript, some factors beyond valence are needed to

categorize emotions. Indeed, our own research suggests that a two (or more) dimensional emotion space manifests early and remains consistent across development (Woodard et al., 2021). But the field does not seem to have widely agreed upon candidates for what those factors might be. Arousal as a component of emotion does have strong intuitive appeal. It fits with everyday folk theories about our experiences: we all have an idea of what it feels like to be in a state of arousal. However, our impressions do not always reflect the structure of underlying processes, and we must rely on scientific evidence to update our beliefs about how things really work. Often, reification hinders this process. Having a word for something does not make that something into a real entity; yet the more widespread and routine the use of a word as a signifier becomes, the more the word appears to validate the existence of the signified. Arousal might refer to some set of processes underlying emotion but evidence for its role in emotional experiences and behavior is at best mixed and imprecise.

The entrenched nature of arousal in discourse about emotion makes it difficult to land on a recommendation for the field to move forward. We wrestled with our decision about what to suggest scholars do to address the limitations of arousal. While we think it would be beneficial for progress in understanding emotion if the use of the term was eliminated, we also recognize that the construct is so engrained this is an unrealistic goal. Previous calls to drop the term from our theoretical vernacular have been well-reasoned but largely ineffective (Neiss, 1988; Silvia, 2005). It seemed to us more practical to encourage a theoretically lighter touch and simply encourage researchers to do more in the service of marshaling a rationale and supporting operational evidence each time they evoke arousal as an explanation or interpretation. Increased specificity in how we describe and define what we are measuring can help us

avoid persisting in pursuit of a construct that may obscure rather than clarify emotion theory. Without more careful justification, arousal might be a barrier that prevents scholars of emotion from fully considering other alternatives.

Each commentary on our manuscript thoughtfully highlights different aspects of the literature that contribute to ambiguity in the term arousal and make it difficult to meaningfully parse data assessing its contributions to emotion. Dror's (in press) framing of historical context provides helpful insight into the origins of this confusion. For example, Dror calls attention to how arousal became in some ways a victim of its own success; an amalgam of developments and explanatory needs across disparate areas of research resulted in it now being a "fuzzy" concept that lacks consistency and clarity. Dror notes (along with Sander, in press) the persistence of definitional and measurement issues. Dror points to historical debates about whether emotional excitement is more than just the mere intensity of the stimuli—strikingly similar to current debates regarding intensity and arousal we outlined in our original manuscript. In this discussion, Dror describes some of the ambiguity around arousal as arising from attempts to bridge physiology-focused approaches with perspectives grounded in self-reports and subjective experiences. This is a tension we highlighted in our original manuscript, with advances in the field of physiology prompting a move away from the concept of a generalized state of physiological arousal followed by emotion researchers incorporating these ideas into the contemporary view that arousal as a psychological experience may or may not coincide with physiology or behavior.

Thayer and Friedman's (in press) commentary elaborates on this tension between physiology and behavior but sees continued utility in the arousal construct. As the oft-used metaphor goes, our own view on the topic of arousal is only afforded by the privilege that we have of standing on the shoulders of the insightful colleagues who came before us (MacGarry, 1955). The writings of Thayer and Friedman have informed our own perspectives, and we are encouraged by the high degree of overlap between our respective views. However, we also note their commentary at times engages in the reasoning that has led to confusion about arousal. Thayer and Friedman draw upon a range of multiply influenced peripheral indices such as heart rate, blood pressure, respiration, and vagal activity, and equate each of these measures as reflecting an *über* construct of physiological arousal. The challenge is that activity across these peripheral systems does not always covary, and variability in patterns of activation across different systems has a range of quite distinct outcomes, including affective states (Carosella et al., 2023; Simon et al., 2022), behavior (Blascovich et al., 2004; Seery, 2011), and memory (Quas et al., 2012; Roozendaal et al., 2009). It is for this reason that we recommend avoiding implicit or explicit assumptions that any single measure reliably reflects a general underlying construct of arousal. Critical questions include determining

how variability in reactivity across physiological systems might better account for specific outcomes of interest and determining whether alternative mechanisms might account for physiological differences. That said, we fully concur with Thayer and Friedman that the studies that they cite suggest a critical role of physiological states in emotional experiences and agree that afferent influences are an exciting and fruitful avenue for emotion research.

Sander's (in press) commentary expands upon ideas regarding potential alternative mechanisms that might explain effects traditionally attributed to arousal. We especially appreciate his discussion of emotional learning and memory. These are domains in which arousal is often cited as a driving mechanism, and ones we did not address them in our original manuscript. While some reports indicate that memory effects covary with subjective arousal ratings (Dolcos & Cabeza, 2002; Ferré et al., 2015), other studies suggest murkier effects. To illustrate with just two examples, there are data consistent with the views that these effects are driven by valence (Adelman & Estes, 2013) or that emotions considered comparable in terms of valence and arousal (e.g., disgust and fear) are prioritized differentially in memory (Chapman et al., 2013). Sander argues these findings may be better explained by differences in the affective relevance of the stimuli. He cites a range of additional terms that have been equated with arousal (e.g., strength, energy, tension, and salience) that contribute to confusion about what, precisely, is being studied. We agree with his analysis and see this argument as consistent with the perspective also highlighted by Dror.

Mechanistically, arousal as a driving factor in memory emerges from studies that have concluded that coactivation of the sympathetic adrenal medullary axis (resulting in norepinephrine release) and hypothalamic–pituitary–adrenal (HPA) axis (resulting in cortisol release) is necessary for affective states such as stress to impact memory (de Kloet & Joëls, 2023; De Quervain et al., 2007; Maheu et al., 2004). However, many studies seeking to assess the impact of emotion on memory are reliant on stimuli that were selected by researchers based upon standardized subjective ratings of arousal (Ahn et al., 2015; Bayer et al., 2014; Glaser et al., 2012; Kensinger et al., 2007). These subjective ratings may or may not covary with sympathetic and HPA activation. More specificity in defining what is being measured (e.g., subjective ratings of arousal vs. cortisol vs. direct indices of sympathetic activation) could help clarify how emotional experiences shape learning and memory. Sander's componential framework of emotion oriented toward increasing this type of specificity represents one potentially useful avenue for researchers moving forward.

One thing seems certain: the usefulness of arousal as a construct is uncertain. If it is to be useful, then formulations need to construe arousal as a multidimensional construct consisting of a number of subcomponents, the identification of which requires greater precision in definition and measurement. Continuing to assume that arousal is a critical component of emotion, without establishing what it is and how it influences

emotion experiences, will likely obfuscate meaningful progress. The philosopher of science Popper keenly noted: “Science does not rest upon solid bedrock. The bold structure of its theories rises, as it were, above a swamp. It is like a building erected on piles. The piles are driven down from above into the swamp, but not down to any natural or ‘given’ base; and when we cease our attempts to drive our piles into a deeper layer, it is not because we have reached firm ground. We simply stop when we are satisfied that they are firm enough to carry the structure, at least for the time being” (Popper, 1959, p. 94). We view the exchanges between our target article and the three commentaries as a fruitful opportunity to both reflect upon the assumptions made in theoretical and empirical scholarship in emotion, as well as an opportunity to use extant research to build some new structures of knowledge that increase our understanding of emotional experiences and behavior. Continued discussion within and across disciplines can only further expand innovative avenues for research.

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