Surprise as an Emotion: A Response to Ortony

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Abstract

We write in response to an article published in this journal by Andrew Ortony titled "Are All 'Basic Emotions' Emotions? A Problem for the (Basic) Emotions Construct." The author claimed that "for all its elevated status as a basic emotion, surprise fails to satisfy the minimal requirements that [he] proposed for something to be an emotion, and if it is not an emotion, it cannot possibly be a basic emotion." Although we acknowledge the concerns brought forth by Ortony, we respectfully disagree with his conclusion about surprise. To make a case against the assertion that surprise is valence-free, we summarize an extensive body of work showing that surprise is indeed valenced—in a specific manner (i.e., *ambiguously* valenced)—and that it meets all of Ortony's criteria for an emotion. In other words, rather than being described as neither positive nor negative, this emotion is either positive or negative. We consider the data with respect to surprise as a basic emotion, and we dispute the definitions of basic emotions as "widely divergent." Future work is needed to continue defining an emotion, and a basic emotion, but we believe this is a worthy effort toward shaping a still evolving field.

Keywords

surprise, ambiguity, valence, basic emotion

We write in response to an article published in this journal titled "Are All 'Basic Emotions' Emotions? A Problem for the (Basic) Emotions Construct" (Ortony, 2022). The author proposed three criteria as minimal requirements for something to qualify as an emotion: "It must be *intentional* (i.e., *about* something), it must be *valenced* (i.e., positive or negative), and it must be *conscious* (i.e., experienced)" (p. 51). We appreciate the simplicity and clarity of Ortony's proposed criteria and agree with these necessary conditions. However, we respectfully disagree with their application when considering surprise as an emotion, or rather, as the author described it, a "basic nonemotion" (p. 57). Specifically, Ortony (2022) maintained that surprise does meet the requirements of being both intentional and conscious but falls short of being classified as an emotion because it is not valenced (i.e., it is valence-free or valence-neutral).

Here, we describe an extensive body of work that demonstrates that surprise is indeed valenced. In so doing, we focus much of our efforts on exploring surprise as it was originally conceptualized in the basic emotions construct—through the representation of the surprised facial expression—although we leave open the possibility that some instances of surprise may deviate from the canonical expression. We are not arguing that surprise is a basic emotion per se but rather that it meets the minimal requirements of being an emotion and very well could be a basic one. Ortony (2022) also asserted that the claims about which are the basic emotions are "widely divergent" and that this represents a fundamental problem in the field. We conclude by making the case that, although the field is still evolving, there is more convergence in the basic emotions construct than previously suggested.

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The Framework for Our Argument

Both of us have published extensively on the topic of the valence of surprise, and we are concerned that the recent article by Ortony (2022) misrepresents the breadth of the literature showing that surprise is in fact valenced. Notably, some work has explored surprised experiences in naturalistic environments and shown evidence for a signature of emotion (Antony et al., 2021). For example, surprise is often characterized as a reward-prediction error that coincides with an emotional response (Gold et al., 2019; Seymour et al., 2005). In other words, when a prediction is violated, one's response—and its associated emotional value—depends on the magnitude of the prediction error and its direction (i.e., precisely how good or bad the outcome was compared with the prediction; Gold et al., 2019). In addition, these prediction errors are thought to motivate new learning so to refine future predictions (Hutchinson & Barrett, 2019).

The link between judgments and experience

Taking another perspective on surprise, much of our work has examined responses to surprised facial expressions, which aligns more closely with emotion perception than experience. Although emotion perception, especially for the facial expressions of others, does not necessarily capture the specificity of one's emotion experience (Barrett et al., 2007; Ortony & Turner, 1990), they are not entirely independent constructs. For instance, emotion expressions are thought of not only as symptoms of emotional states but also as important tools for communication (Adolphs & Anderson, 2018; Fridlund, 1994; Manstead, 1991; Parkinson, 1996). Thus, the signal that is communicated by a facial expression may be just as important as the emotional experience itself. In fact, some have argued that an observer can "reverse engineer" or reconstruct some meaning about the person and the nature of the emotion-eliciting event—including its valence—on the basis of the emotion that is expressed (Frijda, 1986; Hareli & Hess, 2010, 2012).[1] Further, learning theorists argue that one's responses to an expression are, at least in part, driven by the learned associations between the expression and outcome over time (Izard, 1971; see also Adolphs & Anderson, 2018, p. 97; Orr & Lanzetta, 1980). For example, we learn to associate an angry expression with a negative outcome and a happy expression with a positive one. Thus, our appraisals of a surprised facial expression provide clues about both the nonverbal message conveyed in the expression and, to some extent, the experience of the messenger.

Additional evidence for the link between judgments and experience comes from affective neuroscience research—which highlights a shared neural basis for both the perception and experience of emotions—suggesting that there is some underlying response in the perceiver that mimics the expresser (Kober et al., 2008; Lindquist et al., 2012). Taken together, although distinguishing these aspects of affective processing is an important endeavor for scientific research, both are often considered to be the sine qua non of emotion (Adolphs, 2017). For this reason, we offer evidence that supports the notion that surprise is valenced, drawing from our own work on perception of surprised facial expressions. We first address Ortony's assertion that surprise is neutral and then turn to characterizing the valence of surprise.

Surprise Is Valenced

Surprise is not valence-free

Ortony (2022) stated that "surprise is always the result of the registration of a discrepancy between what is encountered and some reference point" (p. 54) and that "all that is needed for valence-neutral surprise is that the surprising event be of no subjective importance to the person evaluating it" (p. 55). In response to the first point, we would argue that this definition is more descriptive of the term "unexpectedness," which is instead a cognitive state that registers a discrepancy between what is encountered and some reference point (see also Roseman, 1996).

This brings us to Ortony's second point about subjective importance. To that end, we argue that the experience of surprise—or any emotion—relies on an experience of subjective importance (see Ely et al., 2015; Ortony, 1988). Indeed, an attempt at reducing subjective importance (i.e., psychological distancing) is an effective strategy for regulating one's subjective (J. I. Davis et al., 2011; Denny & Ochsner, 2014; Kross et al., 2005) and physiological experiences of emotion (Ayduk & Kross, 2010; Ochsner et al., 2012).

In other words, whereas Ortony proposed unexpectedness as a surrogate for surprise, we propose that unexpectedness (i.e., expectancy violation) is necessary *but not sufficient* for surprise (see more on this below). This distinction implies that a prediction error carrying no subjective importance might better be referred to as unexpectedness (and we agree with Ortony that this might not carry any emotional value), whereas surprise represents an emotion that is associated with an experience of unexpectedness that carries subjective importance. And although not all experiences of unexpectedness would register as subjectively important (e.g., trivia), we

argue that experiences that elicit a surprise hold greater subjective importance. Therefore, surprise can be defined as an emotional experience that is the result of an unexpected event of subjective importance.

Surprise is different from neutral

Another approach to exploring the valence of surprise is to compare the surprised expression to the neutral one, given that facial expressions are important signals about the underlying emotional experience (Fernández-Dols & Russell, 2017; Fridlund, 1994; Frijda, 1986). Indeed, surprised expressions elicit greater electrodermal activity—an objective measure of physiological arousal (Neta et al., 2009)—and greater self-reported arousal ratings (Mattek et al., 2017) compared with neutral, and even angry and happy, expressions. Interestingly, arousal is typically positively correlated with valence intensity, in which an increase in arousal is associated with greater positive or negative valence (Brainerd, 2018; Mattek et al., 2017). In contrast to surprised faces, images with a neutral valence (e.g., neutral facial expressions or scenes) do not produce an arousal response in the viewer.

Surprised and neutral expressions are different in another important way: When presented in a temporal sequence with clearly valenced expressions, neutral faces are subject to an anchoring effect (Russell & Fehr, 1987), whereas surprised expressions reveal a context effect (Neta et al., 2011). Specifically, when presented either alongside or in temporal succession with clear expressions, the appraisal of a neutral expression shifts in the opposing direction (i.e., anchored) such that, if the clear expression was positively valenced (e.g., happy), the neutral face is viewed more negatively, and if the anchor was negatively valenced (e.g., sad), the neutral face is viewed more positively. In contrast, in a similar paradigm, some evidence indicates that the appraisal of a surprised face shifts to be in line with the clear expressions, suggesting a contextual influence (see also H. Kim et al., 2004); surprise is viewed more positively when presented with positively valenced (i.e., happy) expressions and more negatively when presented with negatively valenced (i.e., angry) expressions. Taken together, whereas neutral faces are valence-free, surprised faces carry emotional value that is shaped by contextual influence.

Surprise is ambiguously valenced

Ortony (2022) argued that the need to describe surprise as positive or negative suggests that simply saying "surprise" is insufficient, evidencing that surprise is inherently valence-free.[2] In other words, he posited that,

because the valence needs to be explicitly clarified, surprise itself must be inherently neither positive nor negative. In contrast, we believe that these linguistic arguments do not point necessarily to an inherently valence-free surprise but could just as likely suggest that surprise does not have a clear valence. Indeed, the idea that surprise can be pleasant or unpleasant does not suggest that surprise is neutral/unvalenced but rather that it is ambiguous—an emotion that is more flexibly experienced in positive and negative contexts alike—setting it apart in a subtle but important way[3] from the other (basic) emotions (Mattek et al., 2017).

Put another way, we agree with Ortony (2022) that surprise does not appear to have a clear valence. However, an important distinction between his view and ours is that, rather than interpreting this to mean that surprise is neither positive nor negative, we argue that it is *either* positive or negative; rather, surprise is ambiguously valenced.[4] In fact, quite a lot of work has demonstrated that surprise is valenced. For example, using a machine-learning classifier, we have isolated facial features of surprise that transmit subtle yet reliable valence signals, which implies the expression of surprise is both generated and perceived as valenced (M. J. Kim, Mattek, et al., 2017). Moreover, because the expression is used to signal multiple meanings in different contexts—some positive and others negative—the valence appraisal is often modulated by individual differences in the perceiver that are stable (Neta et al., 2009) and generalizable (Harp et al., 2021). In other words, valence signals conveyed by surprised faces are driven by environmental (H. Kim et al., 2004; Neta et al., 2011) and cultural (S.-M. Kim, Kwon, et al., 2017) context.

Notably, context is a powerful force driving our responses to facial expressions (Barrett et al., 2011). But what happens when we see an expression, such as a surprised face, in the absence of contextual cues? If the expression had "intrinsic affective neutrality" (Ortony, 2022, p. 56), one might expect that the perceiver would experience no emotional response (see Phillips et al., 2001). In contrast, we have conducted ample research showing that surprise—when presented without contextual information—is initially negative (Neta et al., 2009, 2021; Neta & Tong, 2016; Neta & Whalen, 2010), even in individuals who ultimately interpret surprised expressions as having a more positive valence. Evidence for this initial or default negativity[5] does not suggest that surprise is intrinsically negative per se but rather that it holds some emotional value that skews negative—a bias that is evident in response to ambiguity even in nonhuman animals (Bateson et al., 2011)—when not accompanied with sufficient contextual cues.

The plausibility of an initial negativity

It is worth noting that Ortony suggested this intrinsic or initial negativity is implausible. For example, returning to the experience of surprise, he suggested that an intrinsic or initial negativity mechanism would play out such that a larger than expected tax refund registers (consciously) as negative and that negativity is then overridden and viewed positively. However, many of these real-life circumstances are embedded within contextual cues that prevent an initial negativity from being consciously registered. For example, let us say you received an unexpected present from a friend. As you open the gift wrap, chances are you will be quite surprised and pleased (so long as it was not a truly ill-intended prank). This is because your expectation—driven in large part by the context of the friend—sets you up to feel positive (i.e., sufficient contextual cues informing your expectations), and so an initial negativity is unlikely.

In this regard, an initial negativity is more likely to occur when the context does not provide you with sufficient information. To better illustrate this point, let us return to the example above—an unexpected gift from a friend. In a context without the friend present (e.g., an unexpected gift simply appears on your front porch), you might experience an initial (even subconscious) negativity: What is that box doing on my front porch? How did it get there? What could be inside? And only on opening the box to find a gift and a card indicating who sent it does an experience of positivity unfold. Likewise, returning to the example of a tax refund, an initial negativity mechanism could play out such that the moment you open the mailbox to find an unexpected letter from the Internal Revenue Service—assuming this letter registers as subjectively important—elicits an initial (even subconscious) negativity because there is not enough information to know whether this will result in a positive or negative outcome. But then, the additional information provided on opening the envelope and finding a check for a larger than expected amount would prevent any registering of negative valence.

In other real-life scenarios, an initial negativity might be more likely to be consciously registered. For example, playing with a jack-in-the-box for the first time will undoubtedly lead to an experience of surprise. Assuming no prior knowledge of how the toy works, you will first likely be startled by the unexpected and sudden appearance of a doll, followed by a sense of relief shortly after realizing what has transpired. Likewise, if people were to jump out from behind a sofa and shout "surprise!" as you entered your home, you would likely be startled initially but soon realize these intruders are your friends throwing a party for you. Thus, some element of initial negativity—whether that negativity is consciously registered or not—is indeed plausible.

Evidence of valence signals

Functional neuroimaging methods have provided useful evidence for the valence of surprise. For example, there is an extensive literature showing that the amygdala is responsive to biologically relevant stimuli, including emotional stimuli (Adolphs, 2010; Whalen, 1998). Several studies sought to answer which specific component of emotional stimuli might be eliciting amygdala activity and suggested that valence was key (Anders et al., 2008; Jin et al., 2015). It follows then that if surprise does carry valence information, this will be reflected in amygdala activity. Functional neuroimaging studies utilizing surprised facial expressions found supporting evidence for this proposition. This line of work relied on various approaches—leveraging individual differences in valence bias (H. Kim et al., 2003; Neta et al., 2013), manipulating contextual information (F. C. Davis et al., 2016; H. Kim et al., 2004), and analyzing facial features of surprise (M. J. Kim et al., 2020; M. J. Kim, Mattek, et al., 2017). These findings revealed that the amygdala showed increased activity in response to the valence information carried by surprised faces. Still other work has explored surprise in real-world contexts—such as sports spectating—and found that surprise is associated with behavioral, physiological, and neural signatures of emotion (Antony et al., 2021). The breadth of these findings lends myriad converging evidence that valence signals were gleaned from surprise (expressions and experiences alike).

Surprise meets the minimal requirements

Given the wealth of evidence suggesting that surprise is not valence-free and that it instead appears to have a valence that varies as a function of individual and contextual factors, we argue here that surprise is in fact valenced. And if it is valenced (and, according to Ortony, it is also intentional and conscious), then it meets Ortony's minimal requirements for being classified as an emotion. In other words, surprise is an intentional, valenced, and conscious state.

Surprise Is an Emotion

In addition to the evidence using the minimal requirements, Ortony (2022) provided other arguments against classifying surprise as an emotion; we attempt to address several of these here. First, we outline (and reiterate) important characteristics that distinguish

surprise (emotion) from unexpectedness (cognitive state). We then describe unique features of surprise and its relationship with other emotions.

The discriminating role of subjective importance

Ortony made the "simplifying assumption that judgments about the unexpectedness of a stimulus and reported surprise are perfectly correlated" to "treat unexpectedness as a surrogate for surprise" (p. 56). This can be a useful assumption in some circumstances, but where it fails, it falls short of a convincing argument against the status of surprise as an emotion. For instance, there are a range of experiences that arise from unexpectedness that might also be described as surprising (e.g., discovering that one's tax refund is greater—or smaller—than expected, receiving an unexpected gift, finding intruders in one's house, hearing unexpected news about the death of a loved one, seeing Will Smith slap Chris Rock at the Academy Awards). However, there are also a range of experiences that arise from the cognitive state of unexpectedness that neither holds subjective importance nor elicits an emotional response (e.g., learning that the underdog won a playoff game against the favored team in a professional sport that you do not follow, discovering the identity of the individual that invented matches). Importantly, we disagree that these events could be described as surprising. Rather, we argue that what Ortony (2022) referred to as a valence-neutral surprise (i.e., a response to a surprising event that has no subjective importance) may be closer to a cognitive state than an emotion. In other words, unexpectedness is a broader umbrella term that includes surprise but is not synonymous with it; as noted above, unexpectedness is necessary but not sufficient for surprise.

To elaborate, let us consider the work cited by Ortony that reported increased corrugator activity in response to trivia that was previously rated more surprising. Ortony (2022) suggested, perhaps rightfully, that this corrugator response could reflect "puzzlement or even concentration." But trivia, although it varies as a function of unexpectedness, may not elicit a true emotion of surprise (i.e., with subjective importance). For example, there may be plenty of people for whom the fact that "the invention of matches is attributed to Johnny Walker" registers as unexpected but of no real consequence or interest. This, then, does not meet the criteria for surprise; and thus, trivia may not serve as the best approach for exploring the valence—either through subjective self-report or objective physiological measures—of surprise. Another study, leveraging perceptions of surprise as a useful indicator about the experience of surprise, found that corrugator responses to surprised facial expressions were valenced to a degree that was similar to angry and happy faces (Neta et al., 2009). And this corrugator response to facial expressions—during a task in which participants were merely asked to categorize the faces as positive or negative—is not likely attributable to a state of puzzlement or concentration.

What kind of emotion is surprise?

Ortony (2022) cited work that argued that surprise was not an emotion given that it combines with other emotions (i.e., they "are not single emotions"; see Oatley & Johnson-Laird, 1987). Although this prior work vacillated on the classification of surprise as a basic emotion, we argue instead that the combination with other emotions does not make surprise any less of an emotion. Surprise is perhaps unique in its time course; the emotion experience, and even expression, can be rather fleeting.[6] As information is further revealed and processed, surprise may naturally transition into happiness (e.g., realizing someone jumping out from behind your sofa was a friend throwing a surprise birthday party), fear (e.g., realizing someone jumping out from behind your sofa was a home invader trying to rob you), anger or sadness (e.g., realizing someone jumping out from behind your sofa was pulling a mean-hearted prank on you), or other emotions with clearer valence (Mattek et al., 2017). Here, in all three examples, your initial reaction would likely be an emotional response (surprise) because you would not have expected someone to jump out from behind your sofa (i.e., unexpectedness that is subjectively important). And this emotional response would likely be characterized by an initial negativity, particularly if you have no prior information about such an event. But this shorter time course does not detract from the discrete emotion of surprise (for further discussion on the persistence of emotions, i.e., the extent to which it is fleeting or lingers, see Adolphs & Anderson, 2018, p. 71). And if surprise is allowed to be an emotion that evolves on a shorter timescale, it can be an emotion that interacts with other emotions. In other words, it is not the case that the "intensity of . . . surprise . . . is modulated by itself" (Ortony, 2022, p. 56) per se but rather that surprise can modulate the intensity of other emotions occurring in close succession (e.g., happiness, fear, anger, sadness).

Overall, among the basic six emotions, plenty of evidence supports the notion that surprise has a unique characteristic—valence ambiguity—and may operate on a different timescale from other (basic) emotions. We argue here that these characteristics should be embraced as a part of surprise and emotion more
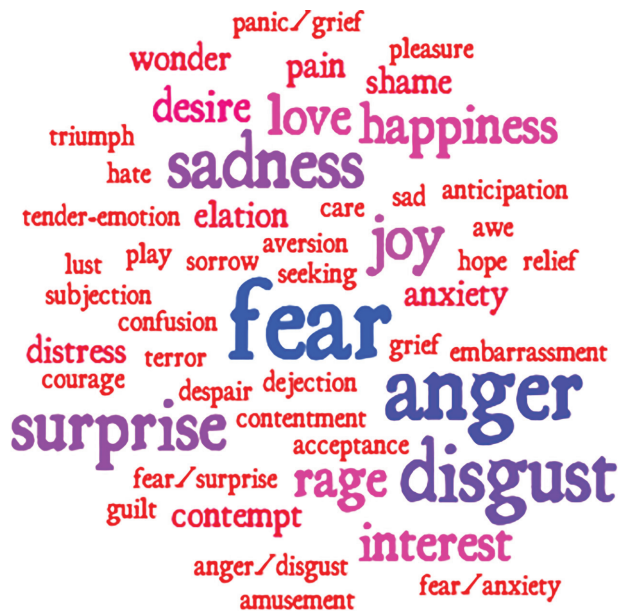
Fig. 1. Convergence of basic emotions. This word cloud was created from the list of words from Table 1 in Ortony (2022) that have been proposed as basic emotions. Both the color and size of each word reflect the frequency of appearing in that table. And indeed, the convergence represented here is likely underestimated because of linguistic factors (conceptually overlapping emotions such as sad and sadness or happiness and joy are represented separately) and because of boundary differences (e.g., "fear/surprise" is its own term but could represent the presence of both fear and surprise).

broadly, not overlooked because of its uniqueness. And perhaps most importantly, if surprise meets the requirements to be classified as an emotion, it very well could be a basic emotion.

Convergence of Basic Emotions

This section represents an area with greater overlap between our views and those presented by Ortony (2022). Indeed, the author described surprise as a "basic nonemotion" (p. 57), so its basicness is perhaps not under debate. However, one final point of contention is that the definition of basic emotions is "widely divergent" (see Table 1 in Ortony, 2022). In fact, an analysis of the frequency with which each emotion was labeled "basic" in this table reveals strikingly high convergence, especially considering the various theorists who proposed these labels had different approaches and were from different subdisciplines (Fig. 1). Of course, there are a high number of words represented, but there is also a relatively clear distinction between words that were represented in only one view of basicness (red, smallest font) and those represented in many views (blue-purple, larger font). It may well be that we, as a field, are not yet able to list the basic emotions and consistently provide an identical answer—as one would when "asking a physical scientist

to list the basic chemical elements [and getting] the same answer regardless of who you ask and, these days, when you ask" (Ortony, 2022, pp. 47–48). However, this does not mean it is not worthy of our investigation (in fact, all the more so) or that there is a "fundamental problem in the field" (Ortony, 2022, p. 58). We argue here that there is relative convergence in the basic emotions construct, and we believe this convergence will continue to grow, thanks in no small part to the work that is both summarized and presented by Ortony (2022).

Conclusions

The basic emotion theory defines emotions as "brief, coherent suites of changes in physiology, cognition, motivation, and expressive and instrumental behavior, evoked by fitness-relevant challenges or opportunities, and serving distinct adaptive functions" (Shiota et al., 2021, p. 143; see also Cacioppo et al., 1997; Cosmides & Tooby, 2000; Keltner & Gross, 1999; Levenson, 1999; Shiota et al., 2017). It follows then that, when an eliciting stimulus is perceived or appraised appropriately, this suite of responses is activated at once (Shiota, in press). Moreover, Adolphs and Anderson (2018) argued for a functional definition of emotion, suggesting that "emotions are functional states that are typically caused by sensory inputs, that typically cause behavioral outputs" (p. 41). Surprise as an emotion appears to check all the boxes, with the coherent suite of changes occurring, perhaps, on a faster timescale.

Ortony (2022) described the basic emotions literature as a "scattered and confusing landscape" (p. 47). We acknowledge the concerns presented by Ortony (2022) and agree with some of his arguments, including the important set of minimal requirements that constitute an emotion. However, we fundamentally disagree that surprise is valence-free. In fact, we provide a wealth of evidence supporting the notion that surprise is (ambiguously) valenced and thus meets all of Ortony's criteria for classification as an emotion. And, if it is an emotion, it very well could be a basic emotion.

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Notes

1. This is not to say that we can always recognize—accurately or consensually—the specific emotion that one is experiencing on the basis of their expression. However, our perceptions of an expression bear resemblance to the range of emotions that can be conveyed by that expression. In other words, a happy expression often signals joy but can be submissive, affiliative, anxious, or a range of other specific emotions. Our perception, then, of happy expressions should represent some or all of these possibilities, perhaps as a function of one's own bias and experiences.

2. Interestingly, in an apparent contradiction, Ortony also argued that some languages (e.g., Mandarin) have a separate word for valence-free surprise (e.g., jing), which also indicates that surprise is inherently valence-free.

3. The feature we refer to here is generalization—a property of emotion that is represented by its link with many different stimuli, as well as many associated outcomes, depending on the context (for a description of this "'fan-in'/'fan-out' architecture," see Adolphs & Anderson, 2018, pp. 75–77).

4. This is not to be confused with ambivalence, which represents the simultaneous co-occurrence of positive and negative emotions (e.g., the joy of graduation co-occurring with the sadness at the closing of an important life chapter; Larsen et al., 2001).

5. But see evidence for a default positivity in aging (Petro, Basyouni, & Neta, 2021; see also Neta & Brock, 2021; Neta & Tong, 2016).

6. It is worth noting here that surprise does not have to occur on a shorter time course. There are circumstances in which this emotional experience—and expression—might be more drawn out. For example, on January 6, 2021, some people might have experienced a prolonged surprise while watching the news in the United States as a riot unfolded at the Capitol Building. Or for a more light-hearted example, anyone that is familiar with the television show "The Masked Singer" might resonate with the experience of discovering the identity of the famous singer, and this surprise—assuming one is interested in the show—might linger.

References

Adolphs, R. (2010). What does the amygdala contribute to social cognition? *Annals of the New York Academy of Sciences*, *1191*(1), 42–61.

Adolphs, R. (2017). How should neuroscience study emotions? By distinguishing emotion states, concepts, and experiences. *Social Cognitive and Affective Neuroscience*, *12*, 24–31.

Adolphs, R., & Anderson, D. J. (2018). *The neuroscience of emotion: A new synthesis*. Princeton University Press.

Anders, S., Eippert, F., Weiskopf, N., & Veit, R. (2008). The human amygdala is sensitive to the valence of pictures and sounds irrespective of arousal: An fMRI study. *Social Cognitive and Affective Neuroscience*, *3*, 233–243.

Antony, J. W., Hartshorne, T. H., Pomeroy, K., Gureckis, T. M., Hasson, U., McDougle, S. D., & Norman, K. A. (2021). Behavioral, physiological, and neural signatures of surprise during naturalistic sports viewing. *Neuron*, *109*(2), 377–390.

Ayduk, Ö., & Kross, E. (2010). Analyzing negative experiences without ruminating: The role of self-distancing in enabling adaptive self-reflection. *Social and Personality Psychology Compass*, *4*(10), 841–854.

Barrett, L. F., Mesquita, B., & Gendron, M. (2011). Context in emotion perception. *Current Directions in Psychological Science*, *20*(5), 286–290.

Barrett, L. F., Mesquita, B., Ochsner, K. N., & Gross, J. J. (2007). The experience of emotion. *Annual Review of Psychology*, *58*, 373–403.

Bateson, M., Desire, S., Gartside, S. E., & Wright, G. A. (2011). Agitated honeybees exhibit pessimistic cognitive biases. *Current Biology*, *21*(12), 1070–1073.

Brainerd, C. J. (2018). The emotional-ambiguity hypothesis: A large-scale test. *Psychological Science*, *29*, 1706–1715. https://doi.org/10.1177/0956797618780353

Cacioppo, J. T., Gardner, W. L., & Berntson, G. G. (1997). Beyond bipolar conceptualizations and measures: The case of attitudes and evaluative space. *Personality and Social Psychology Review*, *1*(1), 3–25.

Cosmides, L., & Tooby, J. (2000). Evolutionary psychology and the emotions. In M. Lewis & J. Haviland-Jones (Eds.), *Handbook of emotions* (pp. 91–115). Guilford Press.

Davis, F. C., Neta, M., Kim, M. J., Moran, J. M., & Whalen, P. J. (2016). Interpreting ambiguous social cues in unpredictable contexts. *Social Cognitive and Affective Neuroscience*, *11*(5), 775–782.

Davis, J. I., Gross, J. J., & Ochsner, K. N. (2011). Psychological distance and emotional experience: What you see is what you get. *Emotion*, *11*(2), 438–444.

Denny, B. T., & Ochsner, K. N. (2014). Behavioral effects of longitudinal training in cognitive reappraisal. *Emotion*, *14*(2), 425–433.

Ely, J., Frankel, A., & Kamenica, E. (2015). Suspense and surprise. *Journal of Political Economy*, *123*(1), 215–260.

Fernández-Dols, J.-M., & Russell, J. A. (Eds.). (2017). *The science of facial expression*. Oxford University Press.

Fridlund, A. J. (1994). *Human facial expression*. Academic Press.

Frijda, N. H. (1986). *The emotions*. Cambridge University Press.

Gold, B. P., Mas-Herrero, E., Zeighami, Y., Benovoy, M., Dagher, A., & Zatorre, R. J. (2019). Musical reward prediction errors engage the nucleus accumbens and motivate learning. *Proceedings of the National Academy of Sciences, USA*, *116*, 3310–3315.

Hareli, S., & Hess, U. (2010). What emotional reactions can tell us about the nature of others: An appraisal perspective

on person perception. *Cognition and Emotion*, *241*(1), 128–140.

Hareli, S., & Hess, U. (2012). The social signal value of emotions. *Cognition & Emotion*, *26*(3), 385–389.

Harp, N. R., Brown, C. C., & Neta, M. (2021). Spring break or heart break? Extending the valence to emotional words. *Social Psychological and Personality Science*, *12*(7), 1392–1401.

Hutchinson, J. B., & Barrett, L. F. (2019). The power of predictions: An emerging paradigm for psychological research. *Current Directions in Psychological Science*, *28*(3), 280–291.

Izard, C. (1971). *The face of emotion*. Appleton-Century-Crofts.

Jin, J., Zelano, C., Gottfried, J. A., & Mohanty, A. (2015). Human amygdala represents the complete spectrum of subjective valence. *Journal of Neuroscience*, *35*, 15145–15156.

Keltner, D., & Gross, J. J. (1999). Functional accounts of emotions. *Cognition & Emotion*, *13*(5), 467–480.

Kim, H., Somerville, L. H., Johnstone, T., Alexander, A. L., & Whalen, P. J. (2003). Inverse amygdala and medial prefrontal cortex responses to surprised faces. *Neuroreport*, *14*(18), 2317–2322.

Kim, H., Somerville, L. H., Johnstone, T., Polis, S., Alexander, A. L., Shin, L. M., & Whalen, P. J. (2004). Contextual modulation of amygdala responsivity to surprised faces. *Journal of Cognitive Neuroscience*, *16*, 1730–1745. https://doi.org/10.1162/0898929042947865

Kim, M. J., Mattek, A. M., Bennett, R. H., Solomon, K. M., Shin, J., & Whalen, P. J. (2017). Human amygdala tracks a feature-based valence signal embedded within the facial expression of surprise. *Journal of Neuroscience*, *37*, 9510–9518. https://doi.org/10.1523/JNEUROSCI.1375-17.2017

Kim, M. J., Mattek, A. M., & Shin, J. (2020). Amygdalostriatal coupling underpins positive but not negative coloring of ambiguous affect. *Cognitive, Affective, and Behavioral Neuroscience*, *20*, 949–960. https://doi.org/10.3758/s13415-020-00812-6

Kim, S.-M., Kwon, Y. -J., Jung, S. -Y., Kim, M. -J., Cho, Y. S., Kim, H. T., Nam, K. -C., Kim, H., Choi, K.-H., & Choi, J.-S. (2017). Development of the Korean Facial Emotion Stimuli: Korea University Facial Expression Collection 2nd Edition. *Frontiers in Psychology*, *8*, Article 769. https://doi.org/10.3389/fpsyg.2017.00769

Kober, H., Barrett, L. F., Joseph, J., Bliss-Moreau, E., Lindquist, K., & Wager, T. D. (2008). Functional grouping and cortical-subcortical interactions in emotion: A meta-analysis of neuroimaging studies. *NeuroImage*, *42*, 998–1031.

Kross, E., Ayduk, O., & Mischel, W. (2005). When asking "why" does not hurt distinguishing rumination from reflective processing of negative emotions. *Psychological Science*, *16*(9), 709–715.

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.

Levenson, R. W. (1999). The intrapersonal functions of emotion. *Cognition & Emotion*, *13*(5), 481–504.

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*, 121–143.

Manstead, A. S. (1991). Emotion in social life. *Cognition & Emotion*, *5*(5–6), 353–362.

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

Neta, M., Berkebile, M. M., & Freeman, J. B. (2021). The dynamic process of ambiguous emotion perception. *Cognition and Emotion*, *35*, 722–729. https://doi.org/10.1080/02699931.2020.1862063

Neta, M., & Brock, R. L. (2021). Social connectedness and negative affect uniquely explain individual differences in response to emotional ambiguity. *Scientific Reports*, *11*, Article 3870. https://doi.org/10.1038/s41598-020-80471-2

Neta, M., Davis, F. C., & Whalen, P. J. (2011). Valence resolution of ambiguous facial expressions using an emotional oddball task. *Emotion*, *11*, 1425–1433. https://doi.org/10.1037/a0022993

Neta, M., Kelley, W. M., & Whalen, P. J. (2013). Neural responses to ambiguity involve domain-general and specific emotion processing systems. *Journal of Cognitive Neuroscience*, *25*(4), 547–557.

Neta, M., Norris, C. J., & Whalen, P. J. (2009). Corrugator muscle responses are associated with individual differences in positivity-negativity bias. *Emotion*, *9*, 640–648. https://doi.org/10.1037/a0016819

Neta, M., & Tong, T. T. (2016). Don't like what you see? Give it time: Longer reaction times associated with increased positive affect. *Emotion*, *16*, 730–739. https://doi.org/10.1037/emo0000181

Neta, M., & Whalen, P. J. (2010). The primacy of negative interpretations when resolving the valence of ambiguous facial expressions. *Psychological Science*, *21*, 901–907. https://doi.org/10.1177/0956797610373934

Oatley, K., & Johnson-Laird, P. N. (1987). Towards a cognitive theory of emotions. *Cognition and Emotion*, *1*, 29–50.

Ochsner, K. N., Silvers, J. A., & Buhle, J. T. (2012). Functional imaging studies of emotion regulation: A synthetic review and evolving model of the cognitive control of emotion. *Annals of the New York Academy of Sciences*, *1251*(1), E1–E24.

Orr, S. P., & Lanzetta, J. T. (1980). Facial expressions of emotion as conditioned stimuli for human autonomic responses. *Journal of Personality and Social Psychology*, *38*(2), 278–282.

Ortony, A. (1988). Subjective importance and computational models of emotions. In V. Hamilton, G. H. Bower, & N. H. Frijda (Eds.), *Cognitive perspectives on emotion and motivation* (Vol. 44, pp. 321–343). Springer. https://doi.org/10.1007/978-94-009-2792-6_13

Ortony, A. (2022). Are all "basic emotions" emotions? A problem for the (basic) emotions construct. *Perspectives on Psychological Science*, *17*, 41–61. https://doi.org/10.1177/1745691620985415

Ortony, A., & Turner, T. J. (1990). What's basic about basic emotions? *Psychological Review*, *97*, 315–331.

Parkinson, B. (1996). Emotions are social. *British Journal of Psychology*, *87*(4), 663–683.

Petro, N. M., Basyouni, R., & Neta, M. (2021). Positivity effect in aging: Evidence for the primacy of positive responses to emotional ambiguity. *Neurobiology of Aging*, *106*, 232–240. https://doi.org/10.1016/j.neurobiolaging.2021.06.015

Phillips, M. L., Medford, N., Young, A. W., Williams, L., Williams, S. C., Bullmore, E. T., . . . Brammer, M. J. (2001). Time courses of left and right amygdalar responses to fearful facial expressions. *Human Brain Mapping*, *12*(4), 193–202.

Roseman, I. J. (1996). Appraisal determinants of emotions: Constructing a more accurate and comprehensive theory. *Cognition & Emotion*, *10*(3), 241–278.

Russell, J. A., & Fehr, B. (1987). Relativity in the perception of emotion in facial expressions. *Journal of Experimental Psychology: General*, *116*, 223–237. https://doi.org/10.1037/0096-3445.116.3.223

Seymour, B., O'Doherty, J. P., Koltzenberg, M., Wiech, K., Frackowiack, R., Friston, K., & Dolan, R. (2005). Opponent appetitive-aversive neural processes underlie predictive learning of pain relief. *Nature Neuroscience*, *8*, 1234–1240.

Shiota, M. N. (in press). Theories of basic and discrete emotions. In *Handbook of emotion theory*. Routledge.

Shiota, M. N., Campos, B., Oveis, C., Hertenstein, M. J., Simon-Thomas, E., & Keltner, D. (2017). Beyond happiness: Building a science of discrete positive emotions. *American Psychologist*, *72*(7), 617–643.

Shiota, M. N., Sauter, D. A., & Desmet, P. M. (2021). What are 'positive' affect and emotion? *Current Opinion in Behavioral Sciences*, *39*, 142–146.

Whalen, P. J. (1998). Fear, vigilance, and ambiguity: Initial neuroimaging studies of the human amygdala. *Current Directions in Psychological Science*, *7*(6), 177–188.