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Emotion Perception as Conceptual Synchrony

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Abstract

Psychological research on emotion perception anchors heavily on an object perception analogy. We present static "cues," such as facial expressions, as objects for perceivers to categorize. Yet in the real world, emotions play out as dynamic multidimensional events. Current theoretical approaches and research methods are limited in their ability to capture this complexity. We draw on insights from a predictive coding account of neural activity and a grounded cognition account of concept representation to conceive of emotion perception as a stream of synchronized conceptualizations between two individuals, which is supported and shaped by language. We articulate how this framework can illuminate the fundamental need to study culture, as well as other sources of conceptual variation, in unpacking conceptual synchrony in emotion. We close by suggesting that the conceptual system provides the necessary flexibility to overcome gaps in emotional synchrony.

Keywords
concepts, culture, prediction, synchrony

> "[O]ne emotion after another crept into her face like objects into a slowly developing picture."
>
> F. Scott Fitzgerald (1925/2013, p. 124)

> "A 'real' person, profoundly as we may sympathize with him, is in a great measure perceptible only through our senses."
>
> Marcel Proust (1922, p. 113)

Fitzgerald captures the experiential simplicity of emotion perception—emotions appear to us as objects that exist out in the world. This experience implicitly guides our scientific investigations. Psychological research on emotion perception is typically designed like an object perception experiment: We present our participants with isolated "cues" such as static, stereotyped portrayals of fear, anger, sadness, etcetera, without context or dynamics (Barrett, Mesquita, & Gendron, 2011; Gendron, Mesquita, & Barrett, 2013). The perceiver's job is to merely detect what is right there, in front of her. A scrunched nose and furrowed brow is disgust, just as surely as a small open container with a handle is a cup.

The object perception analogy does not align with emotion perception as it unfolds in the real world. Emotion perception, like all perception, is an event that unfolds with a significant degree of inference. We cannot directly know the minds of others; we extrapolate from a continuous stream of movements which are filtered through our senses, as Proust asserts. Inferences rely on prior experience, and can vary in how precisely they align with the state of another person—they can be more or less complex (e.g., inferring someone feels bad, when they feel regretful), can differ in focus (e.g., can emphasize action, but not social perspectives), and can even lack shared meaning altogether (as we will see later in our discussion of culture). That is, inferences are graded in how well they approximate the state of another person. The target is also making inferences, but about the sensory inputs in his body (i.e., interoceptions), the situation in which those inputs occur, and what to do next. The "perceiver" must infer those sensations (and how the experiencer makes sense of them) from incomplete information. That is, the perceiver must extrapolate from subtle, variable, and dynamic movements and utterances, embedded within

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a situation, to arrive at an understanding of another's continually evolving internal state. The stream of perceptions that occur in an emotional event can be understood as a dynamic synchrony (and sometimes lack thereof) of embodied conceptual processing between people.

We view language as central to the emergence of conceptual synchrony between individuals. As we have suggested elsewhere, language is particularly critical in the domain of emotion where there is strong variability in the features of a given emotion across instances (Barrett, 2006b, 2009, 2017; Barrett, Lindquist, & Gendron, 2007; Lindquist & Gendron, 2013; Lindquist, Satpute, & Gendron, 2015). Concepts for emotion are built, from early on in development, by harnessing the power of language (Wilson-Mendenhall & Barsalou, 2016). Caregivers use words to scaffold (often, unintentionally) statistical learning about mental states, including emotions (Ruffman, Taumoepeau, & Perkins, 2012). This scaffolding is predictive of the functioning of the conceptual system for emotion later on: Caregiver use of mental state predicts children's later use of mental state language and mental state inferences (on theory of mind and emotion perception tasks). Language does not stop playing a role once emotion concepts emerge, however. Language also appears to serve an organizing role in emotion perception throughout the lifespan (for reviews, see Lindquist, MacCormack, & Shablack, 2015; Lindquist, Satpute, et al., 2015), such that disruptions to language appear to impact emotion perception as well.

In this review, we unpack why language plays a role in emotion perception by articulating a theoretical framework that understands emotion perception as episodes of dynamic conceptual synchrony. Our perspective, which we now refer to as the *theory of constructed emotion* (TCE; formerly the *conceptual act theory*), is informed by recent neuroscience advances: prediction signals, rather than stimulus-driven activity, are hypothesized to be the primary mode of operation in the brain. (We have yet to integrate these advances into a discussion of emotion perception, which we do here.) Similar to recent accounts of communication (Friston & Frith, 2015a, 2015b; von der Lune et al., 2016), we hypothesize that emotion perception proceeds as a coordinated, conceptual dance between individuals, with each individual system *predicting* and adjusting to a multidimensional sensory array. Language, particularly words for mental states and actions, is both implicitly and explicitly involved in this interplay. Words have an implicit role to play by serving as an efficient means of activating prior experiences that are relevant to the given situation (i.e., concept knowledge). Words also have an explicit role to play by allowing us to more directly bridge subjectivity; words can serve as bids for understanding ("Do you feel *sad*?") and a means of efficiently resolving ambiguity ("I'm so *grateful*!"). The extent to which words serve the function of bridging subjectivity is dependent on the conceptual representations they anchor, which we unpack in our discussion of culture.

We begin by overviewing the neuroscience evidence that is foundational for the TCE and that places language and conceptual knowledge in a central role in explaining the generation of emotions (both experiences and perceptions). We then introduce the hypothesis that emotion perception is, fundamentally, conceptual synchrony, redefining the concept of perceptual "accuracy." In doing so, we articulate how *emotions are episodes that are co-constructed between individuals*. As such, we operationally define emotion perception as instances of dyadic interaction, although our perspective has potential explanatory power beyond that narrow definition. This is followed by a discussion of when and how co-construction of emotion breaks down across cultural boundaries. Finally, we suggest that a person's conceptual system is inherently flexible, providing the necessary ingredients to meet the challenges of bridging subjectivity.

Predictive Coding as a Neural Basis of Emotion Perception

Brains are Built for Prediction

Until recently, the prevailing model of neural organization assumed that the brain is structured so that sensory information from the world (i.e., "bottom-up" influences) is a primary driver of perception and action as neural activity sweeps forward in the brain; sensory information is passed along to higher cortical regions that serve cognitive and perceptual functions, ultimately dictating action. This view is inherent in models of emotion perception that assume the brain "decodes" emotion from signals (e.g., facial expressions) in the environment (e.g., Dailey, Cottrell, Padgett, & Adolphs, 2002). Sensory information is initially processed within a core system (e.g., inferior occipital cortex, superior temporal sulcus) and *then* is passed along to an extended network for further processing and elaboration (e.g., medial prefrontal cortex, insular cortex; Haxby & Gobbini, 2011).

Accumulating evidence from neuroanatomy, brain function, and engineering converge on the view, however, that brains do not simply *react* to sensory events in the world; they continually *predict* upcoming sensory events (i.e., "top-down" influences). In this framework, higher cortical levels send descending predictions to lower cortical areas, following the principles of Bayesian probability (Clark, 2013; Friston, 2010; Hohwy, 2013); these predictions are then corrected with incoming sensory input (Chanes & Barrett, 2016). This is not to say that the brain is not responsive to incoming sensory input, but that the response is impacted by the set of predictions which were previously generated.

In this account, the brain runs a generative model of the world, using elements of past experience to anticipate and respond to future sensory events, and (often but not always) corrects those representations for sensory information that was not predicted. Predictions allow a nervous system to function efficiently (i.e., incur the least metabolic cost; Sterling & Laughlin, 2015) by devoting processing resources to the sensory inputs that disagree with prediction signals, called *prediction error*. Using past experience, the brain also predicts which errors are likely to be important and which can safely be ignored; these predictions are called *precision signals*.[1] The brain is not waiting to detect sensory inputs, such as those from the quaver of a voice, the clenching of a fist, or the raising of a brow, and then asking "what is this?" Instead, the brain is continually anticipating the cause of sensory events before they arise by asking, "What will this new sensory input be like?" (Bar, 2009a, 2009b).

The integration of these predictive coding principals with emotion perception is only an emerging topic, but predictive coding has already been elegantly applied to the problem of "communication" more generally (Friston & Frith, 2015a, 2015b; Schilbach et al., 2013; von der Lune et al., 2016). That is, how do brains build models of one another, which are updating over time, in order to infer behavior? Friston and Frith (2015b) describe this in terms of general synchronization, in which the state of one "Bayesian brain" can be used to predict dynamics of another, but incompletely such that "the sequence or trajectory of states may not necessarily look similar" (p. 391). They also articulate a special case of generalized synchrony in which, with sufficient turn taking between systems, the brains achieve identical synchronization. When considered within this framework, the prevailing "accuracy" approach to emotion perception equates perception with identical synchrony (a point we will unpack in a later section). Here, we suggest that emotion perception should be studied as the full range generalized synchrony, where the "model" of another's state is unlikely to exactly match.

Neural Networks for Prediction

In our prior work, we have hypothesized and presented empirical evidence that two of the brain's intrinsic networks—conventionally termed the "default mode" and "salience" networks—are at the core of the brain's generative model (Barrett, 2017; Barrett, Quigley, & Hamilton, 2016; Chanes & Barrett, 2016; Kleckner et al., 2017). In this model, limbic regions of the default mode network initiate predictions as multimodal sensorimotor summaries, which become more detailed as they cascade out to primary sensory and motor regions (see Figure 1A, for a schematized illustration). This proposal is consistent with the hypothesis that the default mode network constructs mental models of the world from different points of view and different time points (Buckner, 2012; Hassabis & Maguire, 2009; Mesulam, 2012) and with the hypothesis that the default mode network "represents" semantic concepts (Binder & Desai, 2011; Binder, Desai, Graves, & Conant, 2009).

Further, we suggested that limbic regions of the salience network issue *precision signals* that tune the internal model with prediction error (i.e., impacting how much the sensory information from the world adjusts the ongoing model). This is consistent with the salience network's role in attention regulation and executive control, particularly (but not exclusively) when it comes to affectively (i.e., allostatically) evocative events (for discussions, see Power et al., 2011; Touroutoglou, Hollenbeck, Dickerson, & Barrett, 2012).

There is evidence that these same networks are at play in emotion. Meta-analyses show that the default mode and salience networks are routinely engaged across instances of emotion perception, emotion experience, and emotion regulation (see Plate 8.4 in Clark-Polner, Wager, Satpute, & Barrett, 2016; see Figure 2 in Lindquist, Satpute, et al., 2015; Lindquist, Wager, Kober, Bliss-Moreau, & Barrett, 2012). Thus, it is plausible that these systems are issuing predictions and precision signals about sensorimotor states during emotional events.

This neuroanatomically inspired model, in which limbic regions serve a central role, suggests that predictions in the brain are ultimately about keeping the body regulated. This is done by coordinating of resources across systems—the autonomic nervous system, endocrine system, and immune system (what scientists call the "internal milieu)—in a balancing process called *allostasis* (Sterling, 2012). The brain must track each system's immediate and long-term needs, as well as available resources, to coordinate trade-offs. Critically, an efficient brain *anticipates* the body's needs and prepares the best actions to satisfy them before they arise (Sterling, 2012; Sterling & Laughlin, 2015).

Words (and Concepts) in the Predictive Brain

Words play a powerful role in the initiation of predictions. From birth, words serve to point out instances in the world that have relevance for allostasis, serving as social invitations to form concepts (Waxman & Gelman, 2010). Words continue to play a critical role because they allow for "highly flexible (and metabolically cheap) sources of priors" in the brain's predictive architecture (Lupyan & Clark, 2015, p. 283). This is because highly irregular or sparse prior instances are overcome with language (for review, see Barrett, 2017). In this way, words provide the individual with a scaffold. Words overcome sparseness by directing attention, communicating intentionality, and organizing shared experience (Chen & Waxman, 2013; Ferry, Hespos, & Waxman, 2010; Waxman & Gelman, 2009; Waxman & Markow, 1995).

In the domain of emotion, words are particularly powerful for issuing predictions due to the low statistical regularity across instances of emotions like anger or fear.[2] For example, there is ample evidence that the facial actions associated with emotion experiences like "sadness," "fear," and "joy" are highly varied across instances (Fernandez-Dols & Crivelli, 2013; Reisenzein, Studtmann, & Horstmann, 2013). Words, like "anger" are critical because they allow individuals to form *situation-specific predictions* about the range of facial actions, physiological changes, social perspectives, and overt behaviors that might occur in a given emotional event (for that person, in that situation).

Words have their power because they do not anchor static concepts that are *retrieved* from the brain. We, along with others, hypothesize that the brain constructs concepts in a context-sensitive way (Barrett, 2017; Barsalou, Simmons, Barbey, & Wilson, 2003; Lupyan & Clark, 2015) to predict upcoming

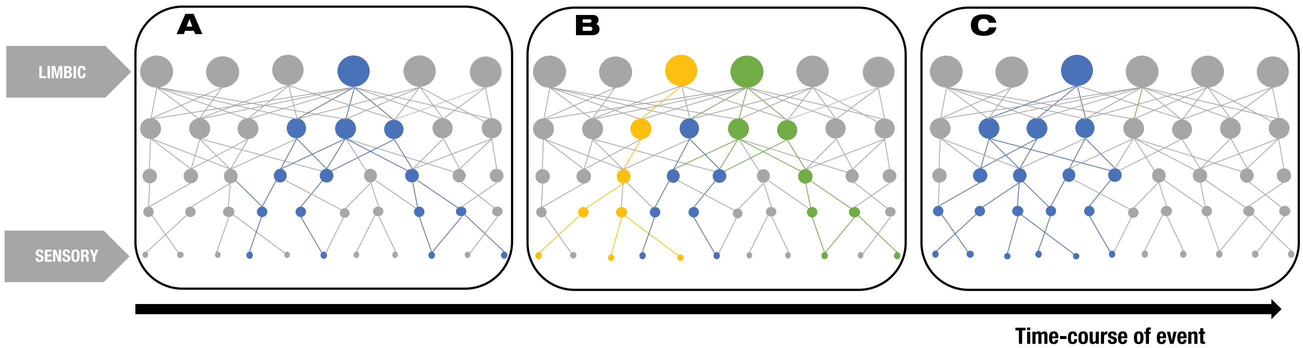

Figure 1. A very simplified depiction of information flow within the cortex. Within the cortical sheet, the arrangement of neurons changes is a predictable way (particularly in the upper cortical layers). Limbic cortices (that launch predictions) have fewer neurons, but they are larger and better connected (because these neurons represent features that are multimodal summaries). As predictions cascade towards primary sensory regions (which contain more neurons that are smaller and less well connected), the sensory predictions become more detailed. Panel A depicts one prediction out of a possible population of predictions (blue); Panel B depicts predictions that are confirmed by sensory input (blue) and error propagated up to limbic regions for predicted (green) and unpredicted sensation (yellow); Panel C depicts an updated prediction (blue). In a real brain, prediction errors from time T are flowing simultaneously with predictions for time T + 1.

sensation. Thus, constructing the concept of "disgust" is equivalent to *predicting* "disgust." A concept is constructed as a population of predictions, which are treated as similar for the purpose of inference (Barrett, 2017; Barsalou, 2009; Murphy, 2002). These predictions are rooted in prior experience; they are partial reenactments—simulations—of the sensory events that have occurred previously and the motor responses that worked well in similar situations. Evidence from cognitive science indicates that concepts are continually shaped by experience and context, such that they cannot be considered free from the contexts in which they are instantiated (Yee & Thompson-Schill, 2016). This is referred to as *situated conceptualization* because the predictions issued are tailored to the affordances of the situation (Barsalou, 1999, 2008).

Empirical evidence is consistent with the hypothesis that concepts (including emotion concepts) are indeed instantiated as *flexible populations* of sensorimotor states (Barsalou, 1999, 2008; Barsalou et al., 2003; Niedenthal, Winkielman, Mondillon, & Vermeulen, 2009; Oosterwijk, Lindquist, Adebayo, & Barrett, 2016; Oosterwijk, Mackey, Wilson-Mendenhall, Winkielman, & Paulus, 2015; Wilson-Mendenhall, Barrett, & Barsalou, 2013, 2015; Wilson-Mendenhall, Barrett, Simmons, & Barsalou, 2011). Data also indicate that predictions issued in instances of emotion are context dependent (Ceulemans, Kuppens, & Mechelen, 2012; Oosterwijk et al., 2016; Oosterwijk et al., 2012; Oosterwijk et al., 2015; Wilson-Mendenhall et al., 2013, 2015; Wilson-Mendenhall et al., 2011). For example, context can shape whether perceivers generate predictions for interoceptions or external actions (Oosterwijk et al., 2015), as well as physical states (more broadly) or social perspectives (Wilson-Mendenhall et al., 2011).

These findings are highly consistent with the view that visceromotor limbic cortices (as well as motor cortex) drive predictions in the brain, issuing predictions across sensory systems. Behavioral evidence corroborates the view that emotion predictions are unpacked as sensorimotor states (for a recent review, see Winkielman, Niedenthal, Wielgosz, Eelen, & Kavanagh, 2015). For example, emotion conceptualization engages facial muscle activity (Halberstadt, Winkielman, Niedenthal, & Dalle, 2009), postural changes (Oosterwijk, Rotteveel, Fischer, & Hess, 2009), as well as other physical responses such as startle (Oosterwijk, Topper, Rotteveel, & Fischer, 2010). Indeed, constructing any concept, even an abstract concept like *generosity*, is inherently multimodal (for a discussion of how abstract concepts are grounded see Barsalou, 2008).

Emotion Perception as Synchronized Conceptualization

Given the centrality of concepts to the workings of the predictive brain, emotion perception can be reframed as synchronized conceptualization (prediction and correction) between two people. We have previously suggested that both "perceivers" and "experiencers" are engaging in situated conceptualization (engaging in prediction), but the sensory signals constraining conceptualization, and the individuals' goals, are distinct (Barrett, 2006b). For example, the "perceiver" may generate visceromotor predictions about the "target," but these cannot be directly constrained by afferent information from the other person's body (interoceptions). The perceiver may have other sources of prediction error tune their internal model, however. As we have seen, emotion conceptualization in the target often takes the form of predictions about visceromotor/motor states. These predictions may manifest in an individual's actions (e.g., his squinted eyes) or observable physiological changes (e.g., his quavering voice).[3] Coupled with any spoken communication, these changes serve as sensory information (i.e., error signal) for the perceiver to tune her predictions about the target's experiences. This set of predictions in based on both the perceiver's prior state, as well as her past experiences with that *emotion* (including experience conferred indirectly through culture). As

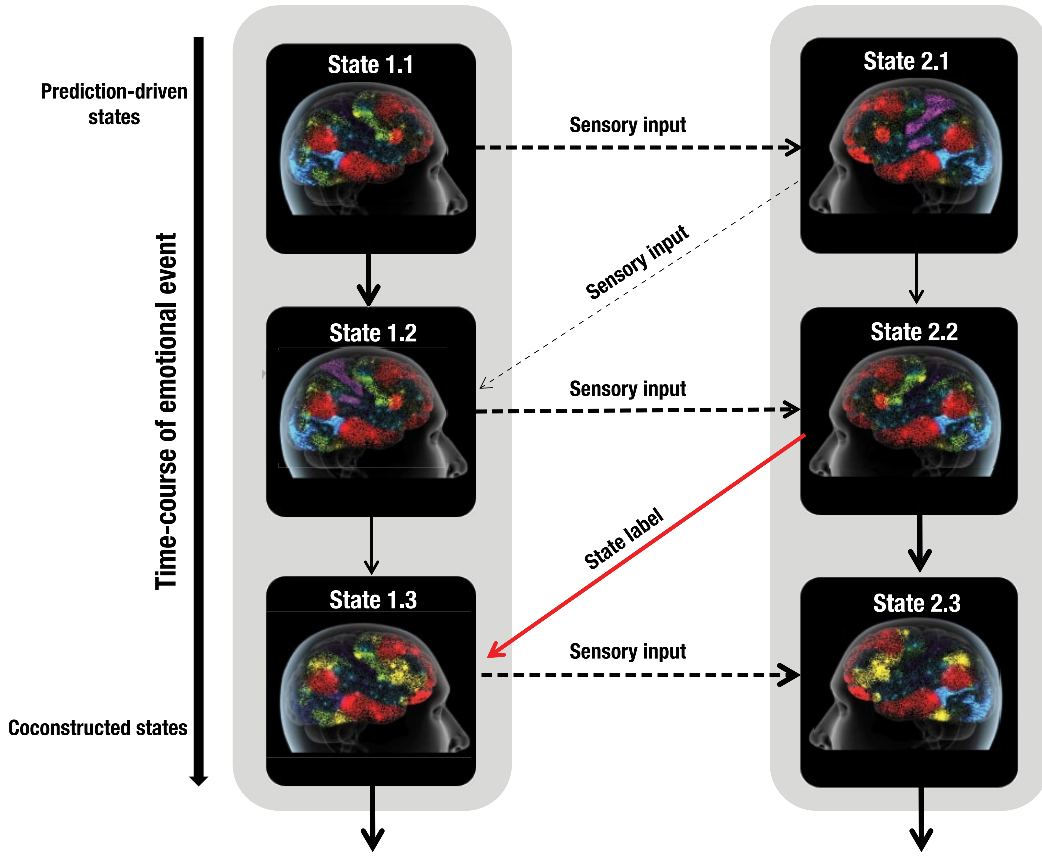

Figure 2. A schematic illustration of co-construction. The left stream depicts the *target* and the right stream the *perceiver*. Intraindividual effects, demonstrating continuity in the running internal model across time, are depicted with solid arrows between states. Interindividual effects, demonstrating co-construction within the dyad are depicted with dotted arrows. These effects occur via sensory input like facial actions, utterances, and body movements. The weight of arrows reflects the *precision* placed on that sensory input—the extent to which prediction error will tune the ongoing model. Arrows on the diagonal represent co-construction effects where the state of the *target* is impacted by the state of the *perceiver*. The red arrow depicts a language-driven co-construction effect, in which an utterance (e.g., "you look sad") impacts the next state of the *target*. The direction of the arrows is simplified for illustrative purposes to emphasize the primary focus of prediction. In the course of a real-world dyadic exchange, the target and perceiver may flip repeatedly, ultimately undermining that distinction.

more information is accrued (i.e., error signals are propagated), predictions are refined; the result is that the perceiver can continually tune their conceptualizations to handle variability in the target's actions and communication.

Synchrony Rather Than Accuracy

The concept of "accuracy" in emotion perception (Ekman, Friesen, & Ellsworth, 1972), has been critiqued due to the difficulties associated with identifying "objective" criteria to define the emotion itself (e.g., consistent and specific brain activity or physiological changes; Barrett, 2006a). Our theoretical account side-steps this issue. Rather than studying "recognition" or "decoding" of specific nonverbal signals, we suggest that emotion perception is best studied as how two (or more) brains achieve agreement about the meaning of sensory signals via conceptualization about emotions.

We prefer the framework of synchrony over accuracy because conceptualizations do not need to *perfectly* match between the target and perceiver (in fact, it would be implausible for situated conceptualizations). In this way, this perspective has parallels with the discussion of generalized synchrony by Friston and Frith (2015b). Brains can be *optimally* coordinated given the circumstances (i.e., whatever is best for prediction and maintenance of allostasis), even if this is quite far from identical synchronization (i.e., matching brain states).

Emotional events are important because they are often instances in which humans regulate (or disrupt) each other's allostasis. But *whose* allostasis is prioritized should dictate the nature of the predictions (both in terms of content and precision). For example, if a perceiver prioritizes the allostasis of their interaction partner, this might result in a metabolically costly exchange (e.g., where precision signals emphasize prediction error and a highly elaborated representation of another's state; e.g., as in Figure 2). This prioritization of another's allostasis (typically at the expense of one's own allostatic maintenance) occurs in many instances of empathy/caregiving. Social prediction is costly, and expending the resources on forming predictions may not always be a metabolically efficient investment (e.g., in someone of lower status who has limited impact on your outcomes; Kraus, Côté, & Keltner, 2010; Muscatell et al., 2012). In those instances, the optimal level of coordination between target and perceiver may be quite low.

This shift, from accuracy to synchrony, has implications for the types of experiments we conduct and the hypotheses that take priority. Existing paradigms rarely allow us to model conceptual synchrony—paradigms require two "conceptual" systems that dynamically interact. One way to accomplish this is by studying dyadic interactions, either within the lab (e.g., the classic empathic accuracy paradigm; Ickes, Stinson, Bissonnette, & Garcia, 1990), or out in the real world (via mobile experience-sampling techniques; e.g., Erbas, Sels, Ceulemans, & Kuppens, 2016), or even with artificial agents (e.g., Gratch & Marsella, 2004). Critically, these paradigms should emphasize the measurement of language and conceptualization in an unconstrained manner (Barrett & Gendron, 2016). The empirical record lends little insight into the words and conceptualizations that are activated in emotion perception events.

Measuring the spontaneous use of language and accompanying conceptualizations will provide a window into variation across individuals. We know from decades of research on *emotional granularity* that people vary in how discretely and specifically they conceptualize emotional episodes (Kashdan, Barrett, & McKnight, 2015). Some people construct specific and nuanced conceptualizations of emotional events that are tightly bound to the situational features (e.g., *irritation* and *jealousy* due to an unwelcome romantic rival), whereas others conceptualize emotions as much broader states (e.g., feeling *bad*), and everything in between (e.g., *anger*). Virtually no research has addressed this type of variation in perceptions of emotion. Further, assuming that there is substantial variation, dyadic considerations abound. It may be that conceptual "fit" is most functional, such that dyads function more effectively when the predictions are aligned, even if they are simplistic (i.e., low in granularity). Further, conceptual variation exists based on prior experiences (e.g., a history of abuse can make the category of anger highly accessible; Pollak & Kistler, 2002), developmental stage (e.g., emotion conceptualizations emerge slowly across development; Widen & Russell, 2008), and individual belief systems (e.g., people vary in folk beliefs about emotion categories as uniform and mechanistically distinct; Lindquist, Gendron, Oosterwijk, & Barrett, 2013). Variation in emotional synchrony may also be rooted in the more general mechanisms of prediction and perception. For example, it has recently been proposed, with empirical support, that problems in social perception in autism spectrum disorder are rooted in issues with generating predictions (von der Lune et al., 2016). Specifically, individuals on the high-functioning end of the autism spectrum failed to generate predictions about upcoming communicative gestures contingent on the actions of another social agent. Indeed, future work is needed to link this perspective more fully to instances of pathology in emotion perception.

Co-construction of Emotion

The term "synchrony" may be insufficient to describe the full scope of "emotion perception." As articulated by Schilbach et al. (2013), building a robust representation of another's state is often best supported by generating and testing predictions within the context of the interaction. In the domain of emotion perception, a member of an interaction dyad (or group) can test their model of another by labeling (i.e., verbalizing a prediction) the other's experience. Critically, this type of "testing" may not only serve to refine the model of the individual testing their predictions, it may in turn change the state of the interaction partner by modifying their predictions (see Figure 2 for a depiction). In this sense, the model of conceptual synchrony described here is really a model of *co-construction*. Synchrony implies a subtle and indirect route to emotion perception, based on the ebb and flow of action and detectable somatovisceral changes in an interaction partner. Co-construction can be more dramatic and direct, such that the predictions of one member of a dyad actually generate a new set of predictions in their dyadic partner. Language is a powerful tool for co-construction. It offers an efficient means of testing (and seeding) a set of predictions about (and in) an interaction partner. In the next section, we highlight how cultures leverage language for the co-construction of emotional meaning (i.e., social reality) and how diversity in cultures can pose a challenge for co-construction.

A Cultural Lens on Co-construction

Cultures Create Social Reality

Concepts, anchored by language, allow for the creation of what Searle (1995) called *social reality*, where meaning is the product of learning and culture, rather than solely based on statistical regularities in sensory properties. Culture fine-tunes the conceptual system based on the set of constraints (e.g., ecological, genetic, and so on) that are placed on that particular group (Jablonka, Lamb, & Zeligowski, 2014). The concepts conferred by a culture provide information that has been useful to other people without every individual having to incur the cost of obtaining that information by trial and error within a single lifetime. Indeed, many definitions of culture are conceptual at the core: We conceive of culture as a shared set of representations (i.e., conceptualizations), and the products of those representations (customs, rituals, artifacts), that are acquired through social learning. People transmit conceptual representations across generations using stories, recipes, and traditions, and also via child-rearing practices and other forms of interpersonal interaction. Each generation shapes the neural systems of the next, with the ultimate consequence of optimizing prediction within that cultural context. Emotion conceptualizations are no exception—they represent a critical domain in which culture optimizes predictions. Emotion concepts prescribe situation-specific actions, and modes of communication that are functional within that cultural context and thus help maintain allostasis.

Co-construction Across Diverse Conceptual Systems

The social reality surrounding emotion is not the same across cultures. Data from anthropology and linguistics have revealed a remarkable amount of diversity in words for and conceptualizations of emotion across different cultural contexts (for reviews, see Lillard, 1998; Lindquist, Gendron, & Satpute, 2016; Mesquita & Frijda, 1992; Russell, 1991), consistent with the idea that the conceptual system is tailored to the constraints of the environment. The implication is that the set of predictions issued in a given context by individuals from distinct cultures may vary widely and lead to gaps in the co-construction of emotion. Variation in concepts can dramatically impact (and sometimes impede) the co-construction of emotions.

One of the most systematic forms of conceptual variation in emotion is whether predictions emphasize situated action (referred to as *opacity of mind* in the anthropology literature; see Robbins & Rumsey, 2008), or mental events (referred to as *mentalizing*). Opaque (action-based) predictions have been widely documented in Pacific Island nations and in our own work with the Himba pastoralist culture in Namibia (Gendron, Roberson, van der Vyver, & Barrett, 2014a, 2014b). This is in contrast to Americans, who infer mental states widely—often in inanimate objects (Gray, Gray, & Wegner, 2007). The emphasis on action versus mental experience can be thought of as a "continuum" (Duranti, 2015). Individuals from East Asian cultures fall closer to the opacity end (consistent with the more general tendency to predict based on situations, rather than internal attributes; Choi, Nisbett, & Norenzayan, 1999; Markus & Kitayama, 1991). For example, Chinese mothers compared to American mothers use less mental state labels but more action language when describing emotional events to their children (Doan & Wang, 2010).

Co-construction of emotion can also be impeded when the concept invoked is not shared across cultures. Despite the tyranny of the English language (Wierzbicka, 1986), recent attempts to catalogue "untranslatable" emotion words have yielded hundreds of examples of concepts that do not have corresponding words in other languages, such as those collected in *The Book of Human Emotions* (Watt Smith, 2016). Even more intriguing is the fact that cultures disagree on what constitutes an "emotion" in the first place—some cultures do not mark emotions with a single linguistic category to identify them as a special kind of mental state (e.g., the Samoans, the Gidjingali aborigines of Australia, the Chewong of Malaysia, the Tahitians, the Ifalukians of Micronesia, the Bimin-Kuskusmin of Papua New Guinea, the Himba of Namibia, the Hadza of Tanzania, and so on; for review see Russell, 1991). This may imply that in those cultures, the types of predictions generated about "emotional" situations do not differ dramatically for those generated about other types of situations. Clearly the implication for co-construction of "emotion" when emotion is not considered a special domain is a question ripe for further inquiry.

Co-constructing meaning may be particularly impeded by words that *appear* to anchor similar sets of predictions across cultures. For example, the English language concept of "shame" has overlapping predictions with the Spanish language concept "*vergüenza*," but the former also emphasizes internal culpability (moral culpability) whereas the latter emphasizes societal pressures (e.g., being criticized; Hurtado de Mendoza, Fernández-Dols, Parrott, & Carrera, 2010). Similarly, translational "equivalents" do not anchor the same predictions about facial muscle movements across Chinese and Western European cultural contexts (Jack, Garrod, Yu, Caldara, & Schyns, 2012).

Issues of co-construction are evident for individuals who relocate to a new cultural context. A mismatch between an individual's emotional conceptualizations and potential interaction partners in a new culture (De Leersnyder, Mesquita, & Kim, 2011) leads to poorer relational well-being (De Leersnyder, Mesquita, Kim, Eom, & Choi, 2014) and physical health (e.g., cardiovascular or respiratory conditions; Consedine, Chentsova-Dutton, & Krivoshekova, 2014), indicating significant disruptions of allostasis. We hypothesize that breakdown in co-construction is likely to manifest more broadly in subtle cultural shifts as well (e.g., work vs. home environment), which begs further empirical attention. Yet, as we outline next, the human conceptual system is built for flexibility, indicating that these challenges of emotional acculturation can be met.

Built for Flexibility: Conceptual Combination and Emotion Acculturation

Humans can use conceptual combination (i.e., combining diverse sets of predictions to form a new set) to construct a potentially limitless number of novel concepts from existing ones (Murphy, 2002). Many instances of conceptual combination are momentary and situation specific—Barsalou (1983) called these "ad hoc" because they are tailored to a given situation (e.g., things you can use to swat a bee). But the process by which we construct these fleeting conceptualizations is actually the same as the process by which we construct what we often think of as stable "concepts" (Barsalou, 1987; Casasanto & Lupyan, 2015): we use prior experience to construct the predictions that will be most functional in a given situation. Conceptual combination is how we can pick up a book about "untranslatable emotions" and make sense of the contents. This capacity can be harnessed for emotion acculturation by more explicitly teaching new emotion concepts and even for inventing new concepts (Barrett, 2017).

Indeed, several studies demonstrated that Americans can form predictions based on emotion concepts that were previously novel to them (e.g., the German concept of *Schadenfreude*, Cikara & Fiske, 2012; or the Japanese concept of *amae*, Niiya, Ellsworth, & Yamaguchi, 2006). But the extent to which individuals construct similar predictions to those of native speakers is likely impacted by the types of predictions involved (Richerson & Boyd, 2005). That is, there will be *content bias* in cultural transmission based on (a) how similar the predictions are to ones that the individual has previously issued and (b) what is valued in a given cultural framework (De Leersnyder, Boiger, & Mesquita, 2013; Tamir et al., 2016).

A second feature that renders the conceptualization so flexible comes from the brain's predictive architecture. Conceptualization is not a punctuated event—predictions (and their modification by prediction error) are continuous, such that predictions are constantly in flux. In the domain of emotion, this is a critical capacity, since the tendency of an individual to update predictions will afford better coordination over time. This will be particularly key when the nature of an individual's conceptualizations is very distinct from those of an interaction partner (such as when two individuals come from very distinct cultural contexts). While updating of predictions is a general feature of the brain, some individuals in some instances may be more or less sensitive to prediction error (i.e., by adjusting precision or error signals). Future research investigating the constraints that lead to the updating of predictions (based on processing error signal), and when they do not, will be necessary to understand the dynamics of co-construction as they unfold across situations and individuals.

Conclusions

Here we have highlighted the central role that emotion conceptualization, anchored in language, plays in emotion perception. We do so by laying out our co-construction account, which integrates across advances in neuroscience and cognitive science to shed new light on emotion perception. We suggest that rather than anchor on specificity or variability in cues for emotion (e.g., facial actions) and how perceivers make sense of these cues in highly constrained lab environments, true advances in the study of emotion perception will result from tackling specificity and variability in how conceptual systems dynamically constrain one another. This framework sheds new light on when and how issues in co-construction of emotion occur and suggests future avenues for harnessing the flexibility of the conceptual system for addressing these issues.

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Notes

1 Precision signals (i.e., the application of attention) provide the means to sample the sensory periphery in a way that is optimized for allostasis and are sent to every sensory system in the brain (for anatomical and functional justifications, see Chanes & Barrett, 2016).

2 Recent meta-analytic summaries of peripheral and central physiology do not reveal consistency and specificity of emotion features (Lindquist et al., 2012; Siegel et al., 2017). Consistency is instead related to the context (e.g., mode of inducement in an experiment) or specific actions (e.g., crying vs. not in an instance of sadness).

3 Similar to views of emotions as encapsulated, evolved mechanisms (for an overview of that alternative account, see Shariff & Tracy, 2011), we do not view facial actions, behaviors, and physiological states as arbitrary. Movements and physiological changes occur in the service of a goal (or set of goals), constrained by the environment. This includes physiological goals (e.g., orofacial rejection of a noxious stimulus) and social goals (e.g., signal warmth) highlighted in evolutionary psychology and behavioral ecology accounts.

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