

Shared Worlds and Shared Minds: A Theory of Collective Learning and a Psychology of Common Knowledge

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The study of observational learning, or learning *from* others, is a cornerstone of the behavioral sciences, because it grounds the continuity, diversity, and innovation inherent to humanity's cultural repertoire within the social learning capacities of individual humans. In contrast, collective learning, or learning *with* others, has been underappreciated in terms of its importance to human cognition, cohesion, and culture. We offer a theory of collective learning, wherein the cognitive capacity of collective attention indicates and represents common knowledge across group members, yielding mutually known representations, emotions, evaluations, and beliefs. By enhancing the comprehension of and cohesion with fellow group members, collective attention facilitates communication, remembering, and problem-solving in human groups. We also discuss the implications of collective learning theory for the development of collective identities, social norms, and strategic cooperation.

Keywords: collective attention, common knowledge, social learning

Humans have proliferated as a species because of their capacity for culture, cooperation, and social learning among individuals and across generations. The growing literature on human cultural accumulation and social learning portrays a process of learning *from* other people, whether they are contemporaries or ancestral role models. Complementary to the central importance of learning from others, the human capacity for learning *with* others—by cognitively prioritizing objects, information, and events under collective attention—is an underemphasized component of human cognition, cohesion, and culture. Here we offer a social–cognitive account of human collaboration that allows multiple minds to work together, harnessing superior cognitive power, a multiplicity of perspectives, and a division of labor.

One challenge for an account of human collaboration is to identify the factors that enable cognitive coordination within a group. Should we look for mental mechanisms that reside within

individuals (Turner, 1982), or group processes that happen among them (Thompson & Fine, 1999)? An integration of these perspectives would describe how cognitive mechanisms within individuals enable social processes among them. By conceptualizing specific cognitive mechanisms that lead to particular social processes, scholars can articulate truly *social–cognitive* theories in which cognitive and social processes inform one another.

Our thesis is inspired by work on shared mental states, including joint attention (Bruner, 1995), shared intentionality (Tomasello, Carpenter, Call, Behne, & Moll, 2005), shared emotions (Rimé, 2009), shared attitudes (Festinger, 1954), and shared beliefs (Bartol, 2000), all of which reflect the distinctively human ability to collaborate together through the experience of a commonly known world (Echterhoff, Higgins, & Levine, 2009). We detail the psychological state that indicates and enables the representation of what is *knowingly known* to all, or common knowledge (Vanderschraaf & Sillari, 2014), through the first-person plural perspective of a collective agent. As a result, individual minds can more easily pool their cognitive resources—communicating, remembering, and problem-solving together—producing superior solutions to common problems compared with what could be attained by any one mind alone.

Observational, or social, learning is often described as the primary mechanism for transmitting *cultural recipes* from one generation to the next. By selectively copying others, humans are able to reproduce success and avoid costly errors (Dean, Kendal, Schapiro, Thierry, & Laland, 2012; Henrich, 2015; Kendal et al., 2018). In such models, cultural inventors, acting alone, improve on the efforts of previous generations (Boyd & Richerson, 1985).

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Here, we posit that cultural innovations are also the product of collective learning and collaborative cognition. Whereas copying focuses on cultural innovation as a serial process, where knowledge is transmitted, and occasionally improved upon, from one learner to another, collective learning allows for an understanding of cultural innovation as a parallel process, where novel knowledge emerges through the interactions of multiple learners attending, knowing, and thinking together.

At the center of collective learning theory is a social psychological solution to the paradox of common knowledge (Section 1), wherein a specific psychological state of collective attention can indicate what is common knowledge (Section 2), facilitate cognitive alignment among group members (Section 3), and help mentally represent shared subjective states as common knowledge (Section 4). In all, we describe how collective learning enhances social coordination and social motivation, facilitating group communication, memory, and problem-solving (Section 5; Figure 1). We also discuss the implications of collective learning for the development of collective identities, social norms, and strategic cooperation (Section 6).

The Paradox of Common Knowledge

Common knowledge is a central idea in social coordination within philosophy (Hume, 1738; Lewis, 1969), linguistics (Clark, 1985, 1992), economics (Aumann, 1976; Schelling, 1960), sociology (Friedell, 1969), organizational science (Glick, 1985; Schneider, Ehrhart, & Macey, 2013), and psychology (Tooby & Cosmides, 2010; Thomas, DeScioli, Haque, & Pinker, 2014). Across disciplines, common knowledge is understood to be critical to success in certain kinds of communication, coordination, and collective action among individuals. From knowing where to find your partners, to communicating with them, to resolving public goods dilemmas, to following social norms, success in social interactions often depends on common knowledge.

To begin, common knowledge is not simply known by all involved; all parties involved must also *know* that everyone knows it (Vanderschraaf & Sillari, 2014). For instance, the fact that two friends each know that it is raining does not entail common knowledge unless both of them knows that they both know that it is raining. Whereas the term *mutual knowledge* has been used to refer to information that is privately known by all parties, *common knowledge* additionally requires a collective awareness of this mutual knowledge.

Imagine that you are stuck in a meeting that has gone on far too long. You are looking forward to having a picnic lunch with your coworker, who is also at the same meeting and is smiling at you,

presumably anticipating the picnic. Looking through a window you can see that it begins pouring rain, ruining your picnic plans. Now, you look back at your coworker, and to your amazement they are still smiling. This puzzles you. Perhaps, you think, they do not see that it is raining. Alternatively, perhaps the smile is meant to show consolation for your feelings at the turn of events. This signal of consolation will not be understood by you as such unless you know that the coworker knows that you know that it is raining. This implies that if the coworker wanted you to understand their smile as an expression of consolation, they must know that you know that they know that you know that it is raining.

The above scenario shows that distinct levels of knowledge about another's knowledge about one's own knowledge matter for the horizon of human communication and understanding. Critically, common knowledge of the rain, where both you and the coworker *are fully assured* that you both know that it is raining, is out of reach in this scenario. That is, you might *not* know that they know that you know that they know that you know that it was raining. Undoubtedly, people engage in such metathinking to some degree, especially in complex strategic interactions. However, conjuring up higher and higher levels of metaknowledge about each other's knowledge eventually becomes too onerous, and then inconceivable. Attainment of common knowledge via this route is both logically and psychologically untenable. Accordingly, any account of common knowledge that requires such high levels of metathinking must be mistaken.

Given the difficulties, it is fair to ask whether the attainment of common knowledge is relevant to human psychology. There is both an empirical and conceptual case, however, for the importance of common knowledge in supporting social coordination. In deciding whether to socially coordinate, people are highly sensitive to the distinctions between common knowledge and other knowledge states that fall short (De Freitas, Thomas, DeScioli, & Pinker, 2019). Specifically, Thomas et al. (2014) found that people are more likely to coordinate with one another when instructions in a coordination game were given over a loud speaker, hence presumably constituting common knowledge, as compared with when instructions were secondary knowledge (I know that you know), or tertiary knowledge (I know that you know that I know).

There are also logical grounds to believe that common knowledge is critical to social coordination, such as the famous coordinated attack problem (Halpern, 1986; also Rubinstein, 1989), in which two allied armies want to coordinate an attack on a common enemy. As Rubinstein (1989) shows, no amount of back and forth messages between the armies guarantees common knowledge, making it more advantageous for both armies to stay put rather than to risk attacking alone. The paradox of common knowledge is as important as it is elusive.

The paradox of common knowledge is rooted in the logical distinction between one's own knowledge and that of others. It is this distinction that allows for the infinite regress of mirror-in-mirror imagining of mind A thinking about mind B thinking about mind A. Although the distinction between one's own knowledge and that of others is real, all communicative acts require some shared understanding. As Tomasello (2014, 2019) notes, communication partners must assume that they are discussing the same world to disagree about that world. That is, we must assume that we know about the same rain to disagree on whether the rain is wanted or unwanted.

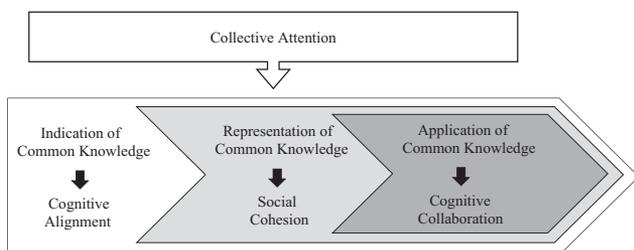


Figure 1. Conceptual overview.

Of course, people can communicate without common knowledge, suggesting that it is not always strictly necessary for social coordination. However, if there were a cognitively frugal psychological capacity that could indicate and represent common knowledge, it would facilitate social coordination, as it would lessen recursive doubts about others' knowledge. Such a psychological capacity would give a significant advantage in communicating, remembering, and problem-solving together in groups. The critical question is thus the following: Is there a psychological capacity that allows individuals to achieve common knowledge about the world?

Collective attention is one possibility (see Figure 1). Depending on the object of attention, collective attention can (a) indicate common knowledge, reducing doubt about what others know and increasing cognitive alignment among group members, and (b) represent common knowledge, increasing social cohesion and motivating social coordination among group members. Whereas the former allows for a psychological representation of a common world, the latter allows for a psychological representation of a common mind.

The Collective Attention Solution

In the first year of life, human infants begin to coordinate their attention with that of another person (Meltzoff, 2007; Scaife & Bruner, 1975), establishing a common point of reference. This behavioral coordination of attention is referred to as joint attention (Baron-Cohen, 1995; Bruner, 1983; Mundy & Newell, 2007; Tomasello, 1999). The importance of joint attention behavior begins with early learning and development (e.g., Baldwin, 1995; Mundy, Sigman, & Kasari, 1990, 1994; Tomasello & Farrar, 1986; Tomasello, 1995).

Rather than focusing on joint attention behavior per se, here we examine the cognitive capacities (Baron-Cohen, 1995) that support it. That is, we describe the mental operations that register coattention, enabling the understanding of the conditions under which attending together is relevant to human cognition, cohesion, and culture. Specifically, we will argue that the adoption of a first-person plural perspective, or collective attention (Shteynberg, 2009, 2010, 2014, 2015a, 2015b, 2018),¹ is unique as a psychological foundation of common knowledge. The challenge of postulating a psychological state that indicates common knowledge is twofold. On one hand, the psychological state has to be robust enough to indicate mutual knowledge of mutual knowledge; on the other hand, the mental state has to be efficient, or cognitively frugal, given the high frequency of social coordination in everyday human life.

Tellingly, psychological accounts of common knowledge have typically avoided discussion of mental states that signal common knowledge among perceivers. For instance, Tooby and Cosmides (2010, p. 204) suggest that there is no need for "deliberative representation of others' knowledge states at all." Thomas et al. (2014, p. 658) propose that common knowledge "can be activated in people's minds by any salient public signal . . . such as a message broadcasted on a loudspeaker." Or, as Chwe (2001, p. 77) puts it: "When we make eye contact . . . I can simply infer from past experience that usually when we make eye contact, common knowledge is formed." Whereas we agree with all three of the above perspectives, they do not attempt to provide a psychological

account of common knowledge, wherein particular mental states signal and/or constitute the representation of common knowledge. Here we attempt to do so via the psychological mechanism of collective attention (Shteynberg, 2014, 2015a, 2015b, 2018).

Collective Attention

Collective attention involves a first-person plural perspective, where the individual experiences that *we are attending* to some aspect of the world (Shteynberg, 2015a, p. 581). The awareness that we are attending to some aspect of the world also resonates with the concepts of plural prereflective self-awareness (Schmid, 2014), communal awareness (Searle, 1995), and the we-perspective (Tuomela, 2007) in the philosophical literature.

Our emphasis on collective attention is also in line with calls for greater integration of we-mode theories into cognitive science (Gallotti & Frith, 2013). Specifically, as Gallotti and Frith (2013) state: "We shall refer to these processes as we-mode processes (first-person plural). . . One major reason for taking this route is dissatisfaction with the assumption that interactions are always guided by representations in the head of agents representing states of affairs, including others' minds, from the perspective of the thinking and experiencing subject 'I' (p. 163)."

Collective attention is a representation of a unitary *we* attending to some *thing*. Logically, the formation of the first-person plural perspective is premised on a psychological connection between the self and another agent (or agents) that is sufficient to represent a collective agent and dissolve the distinction between the individual perspectives of self and other. Empirically, there is some evidence suggesting that a minimal group manipulation is sufficient for generating a representation of a collective agent in coattentive experiences (Shteynberg, 2015a, 2018). Furthermore, because collective attention is the representation of a collective agent attending to something, the mere representation of a collective agent does not constitute collective attention. Rather, beyond being merely extant, the collective agent must be represented as attending to some aspect of the world (Shteynberg, 2015a, 2018).

Collective attention is a situationally informed mental state (Allport, 1985) that can arise as a result of the explicit or implied attention of one's social group. The awareness that we are attending can arise through coattention, whether it be observed, communicated, imagined, or implied by the situation. Like any other psychological state, collective attention may or may not be commensurate with reality. Mistaken states of collective attention are possible, both about the target attended to and the fact of collective attention itself. Yet, humans' strong interest in attending together (e.g., Liszkowski, Carpenter, Henning, Striano, & Tomasello, 2004), combined with their ability to do so (e.g., Kobayashi & Kohshima, 2001; Sweeny & Whitney, 2014; Tomasello, Hare, Lehmann, & Call, 2007), suggest that psychological states of collective attention have the capacity to be accurate, especially when combined with information about the attentional habits of group members. Accuracy, in this context, is defined intersubjectively, wherein a person's representation of collective attention matches supposed coattendants' representations

¹ Past research has referred to collective attention as shared attention. We believe that the term *collective attention* is preferable to *shared attention* because the latter has multiple meanings in the literature.

of collective attention in the moment. Stronger and more certain collective attention states occur in situations where there are greater expectations of and evidence for simultaneous coattention with in-group others. In contrast, weaker and less certain collective attention states occur in situations where there are fewer expectations of and evidence for simultaneous coattention with in-group others.

Collective Attention Indicates Common Knowledge

We argue that collective attention is an apt signal of what is commonly known, because (a) it is cognitively frugal, (b) it is represented in situational contexts where common knowledge is thought to arise, and (c) it is a representation of a unified collective perspective, obviating the need for higher-order representations.

Collective attention is cognitively frugal because it only requires the representation of one dyadic relationship—that between the attending collective self and the attended information (e.g., we are attending to X), which is cognitively more frugal than the representation of multiple dyadic relationships (i.e., I am attending to X, and you are attending to X; Mundy & Newell, 2007) or a triadic relationship (i.e., you see that I am attending to X; Baron-Cohen, 1995).

Common knowledge is attained when people receive information simultaneously and publicly (Vanderschraaf & Sillari, 2014)—when the awareness that we are attending is most likely to occur (Shteynberg, 2015a). The reception of information simultaneously and publicly in the context of a minimal in-group, or an *us*, is also the situation in which coattention has an empirically observable impact on cognition, emotion, motivation, and action (Shteynberg, 2018). Because collective attention is more likely to occur within collaborative and in-group settings, it functions to facilitate the emergence of common knowledge within groups that are likely to collaborate in the future (Shteynberg, 2015a). In contrast, states of collective attention do not appear to be readily accessed when coattending with relationally distant others, placing boundary conditions on the collective learning process.

Most importantly, however, the first-person plural *we* perspective requires a collective *unified* attentional perspective on a given target. This effectively reduces doubt about the fact of somebody else's awareness (e.g., I know that you know, but do you know that I know?). That is, to the extent that a person is able to represent a collective attentional perspective, there is no *other* perspective that could be lacking in knowledge. It is built into the content of the very representation, obviating the need to supply other representations to achieve common knowledge. Specifically, we propose that the emergence of a unified collective agent depends on the momentary suppression of the individual agentic perspectives that it subsumes. The idea that the collective agent is based on the erosion of the distinction between the self and the other is central to scholarship on collective self-representation (Brewer & Gardner, 1996; Turner, Hogg, Oakes, Reicher, & Wetherell, 1987), where constituent members are regarded as undifferentiated exemplars of the collective agent. Put differently, the cognitive accessibility (Higgins, 1996) of a collective agent can increase to the extent that the cognitive accessibility of competing agentic perspectives diminishes (Turner, 1982). As a result, when a given object becomes represented from a collective point of view, recur-

sive doubts about self-other knowledge of that object need not arise during the moment of perception.

In cooperative activity (i.e., we are attending to the plan), no agent needs to doubt mutual awareness of the plan, particularly when the *experienced* delivery of information is transparently simultaneous, either through public contexts (e.g., dinner tables, amphitheatres, stadiums, and town squares) or through public technologies (e.g., microphones, telephones, TV, and social media). If the arrival of the message is not transparently simultaneous, however, each party may have reason to doubt whether the other party is aware of the message, hampering coordination in the moment.

Other psychological solutions for preventing higher-order doubt are less successful. First, when the cognitive representation involves two dyadic relationships (i.e., I am attending to the rain, and my friend is attending to the rain), person A may doubt that person B is aware of person A's attention (i.e., I wonder if my friend sees that I am attending to the rain). Moreover, even when second-order awareness is attained (i.e., my friend sees that I am attending to the rain), the coattendeo may question third-order awareness (i.e., although my friend sees that I am attending to the rain, I wonder whether my friend sees that I see her attending to the rain).

Indeed, any cognitive mechanism that represents coattention in *I* and *you* terms encourages greater doubt about whether common knowledge is achieved. Even if one level of epistemic confidence is attained, higher-order forms of doubt can always arise. Conversely, the first-person plural perspective of *our* attention leaves little reason to doubt that the attended-to target is known to *us*, because there is only one collective perspective on the given target.

Collective attention does not relieve the agent from all types of doubt, but it does limit recursive doubt about self-other knowledge. In all, the significance of collective attention lies in the psychological representation of a unitary, collective, and attending agent. This provides a fast, frugal, and reliable signal of common knowledge, enabling human coordination in action and thought.

Collective Attention Versus Observational Learning

There are two key differences between collective attention (coattending with others) and observational learning (finding out what others already know) in how they relate to common knowledge. First, when one discovers through observational learning what others already know, the discovery is one-sided. In these situations, recognition of mutual awareness, and hence indication of common knowledge, is likely to be absent. The situation is similar to when information is learned publicly, but not simultaneously. Whereas the fact that it is raining is publicly available, one does not know whether a potential collaborator is aware of the rain (and if they are aware, whether they are aware of your awareness, and so on). As illustrated in the example earlier, this limits the horizon of human communication and understanding. The promise of everyone becoming mutually aware of the rain *eventually* provides no relief for parties attempting to communicate and collaborate in the moment.

In the case of public information received by all parties at different times (e.g., reading the latest article about social learning), collaborative partners often explicitly affirm their common knowledge ("did you read that new article?") before they use it as a basis for social coordination. Simultaneous coattention, in con-

trast, eliminates the need for explicit verification of common knowledge, allowing for more dynamic social responses to unfolding events.

Finally, the copying of others' past attention may be insufficient to create common knowledge because information attended to by others *may no longer be available*. Human cognitive mechanisms evolved in a world of ephemeral events, when collective attention to a target was a unique opportunity to build common knowledge.

Collective Attention Versus the Impersonal Standpoint

The experience of *our* attention to the world involves the experience from a particular group perspective. Unlike the bird's-eye view perspective (Tomasello, 2019), or the impersonal standpoint (Nagel, 1970, 1986), *our* perspective is *ours*; it is in no way neutral or devoid of perspective. Indeed, the standpoint is one of a personal collective. Specifically, the rain is under *our* attention, and other onlookers may or *may not* take part.

Moreover, collective attention need not involve any representation of the *I* or the *You*. As such, self-other equivalence (e.g., Tomasello, 2019) in relation to the target of collective attention is untenable. That is, when the rain is represented or experienced as under collective attention, it is not that *I* and *You* attend to it identically and/or interchangeably, as neither *I* nor *You* are represented, in relation to the rain. The rain is simply presented as the object of *our* attention. Collective attention is not a representation of an impersonal perspective (Nagel, 1970, 1986), but rather an irreducibly and uncompromisingly intersubjective standpoint (Shteynberg, 2014).

Thus far, we have described how collective attention limits doubts about common knowledge, without detailing how collective attention can mentally represent common knowledge. In the next section, we review the mechanisms by which collective attention helps to synchronize the mental states of coattending group members, promoting cognitive alignment, leading to the eventual mental representation of common knowledge.

From Collective Attention to Cognitive Alignment

Information that is believed to be attended together receives more cognitive resources (for reviews see Shteynberg, 2015a, 2018), wherein targets of collective attention receive a greater share of working memory (Franconeri, Alvarez, & Cavanagh,

2013), resulting in higher cognitive accessibility (Higgins, 1996). Attending together improves recall memory, amplifies emotions, intensifies attitudes, increases goal pursuit, and strengthens behavioral learning (Boothby, Clark, & Bargh, 2014; Boothby, Smith, Clark, & Bargh, 2016, 2017; Elekes, Bródy, Halász, & Király, 2016; Eskenazi, Doerrfeld, Logan, Knoblich, & Sebanz, 2013; He, Lever, & Humphreys, 2011; He, Sebanz, Sui, & Humphreys, 2014; Shteynberg, 2010; Shteynberg, Bramlett, Fles, & Cameron, 2016; Shteynberg, Hirsh, Apfelbaum, et al., 2014; Shteynberg, Hirsh, Galinsky, & Knight, 2014; Shteynberg & Galinsky, 2011; Wagner, Giesen, Knäusenberger, & Echterhoff, 2017).

Although these empirical studies differ in the targets that are attended together (e.g., words, positive/negative images, goals), and hence the consequences of coattending (e.g., memory, affective intensity, goal pursuit), a single psychological process can account for this diversity: the psychological state of collective attention summons greater cognitive resources (i.e., greater share of working memory) to increase the cognitive accessibility of the coattending targets. Words under collective attention are better remembered, valenced images under collective attention evoke greater emotional responses, goals under collective attention result in stronger motivations, and behaviors under collective attention are more faithfully enacted.

For instance, in one experiment, participants who were led to believe they collectively attended to a written passage, using shared online avatars to evoke a *we* perspective—wherein the self is categorized as an undifferentiated exemplar of the group (Tajfel, Billig, Bundy, & Flament, 1971)—were more likely to reproduce the style of the passage in their own writing (see Figure 2; Shteynberg & Apfelbaum, 2013). In one control condition, participants read the same passage together, but were represented by different animal avatars. In another control condition, participants all had the same avatar, but appeared to be attending to different passages. In the final control condition, participants had both distinct animal avatars and distinct written passages. Enhanced learning occurred only in the collective attention condition and not in any of the control conditions.

A follow-up experiment showed that enhanced learning was observed only when participants believed the coattention was simultaneous with group members (as opposed to attending asynchronously, or alone). These findings suggest that cues to simul-

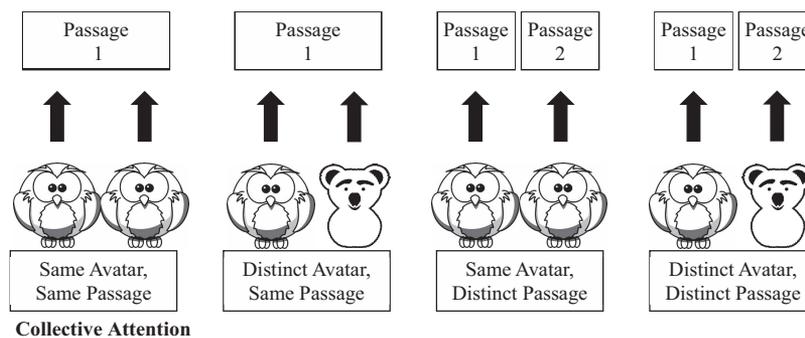


Figure 2. Shared online avatar paradigm in Shteynberg & Apfelbaum, 2013, Study 1. Avatars are simplified for presentational purposes.

taneous coattention engage the sense that “we are attending” to a specific stimulus (Shteynberg & Apfelbaum, 2013).

Variations on the above studies, all evoking minimal collective identification during simultaneous coattention, have shown the same augmentation of learning in the domains of recognition memory (Shteynberg, 2010), goal pursuit (Shteynberg & Galinsky, 2011), and affect formation (Shteynberg, Hirsh, Apfelbaum, et al., 2014). For instance, in Shteynberg (2010), participants were led to believe they either coattended a list of words within (a) a minimal group, consisting of participants who appeared to choose the same avatar colors, or (b) a group of participants who appeared to choose distinct avatar colors. The results suggested that recognition memory for the coattended words was superior in the minimal group (for similar results see Elekes et al., 2016; Eskenazi et al., 2013; He et al., 2011, 2014; Wagner et al., 2017). Likewise, Shteynberg and Galinsky (2011) used the same minimal group avatar manipulation in a study where participants were given specific goals, finding that goal pursuit efforts were particularly high when the goal was collectively attended (for similar findings see Walton, Cohen, Cwir, & Spencer, 2012). In the affect formation domain, collective attention increased positive or negative affect toward positive or negative imagery, respectively (Boothby et al., 2014, 2016; Shteynberg, Hirsh, Apfelbaum, et al., 2014).

Other studies also suggest that learning is increased for people who are collectively identified at the moment of coattention (Skorich, Gash, Stalker, Zheng, & Haslam, 2017). Individuals with autism, however, do not show greater learning under collective attention (Skorich et al., 2017), suggesting either a lack of a first-person plural perspective or a strong inhibition to its use.

In sum, collective attention is a psychological capacity whereby all coattending agents cognitively prioritize collectively attended stimuli over nonshared stimuli, yielding cognitive alignment among the coattendants. That is, when collective attention is accurately represented among all coattendants, there are at least three sociocognitive consequences: (a) cognitive prioritization of the shared stimulus by the self, (b) cognitive prioritization of the shared stimulus by other coattendants, and hence (c) a greater likelihood of cognitive alignment across coattending individuals.

From Collective Attention to Common Knowledge

Under collective attention, increased cognitive alignment makes it more likely that the *cognitive alignment itself* will become an object of collective attention (see Figure 3). This mental representation of common knowledge (i.e., *we are attending to our subjective state*) is a critical motivator of social coordination. Collective attention to the fact that *we know* that it is raining (i.e., our knowledge of the rain) is a representation of common mental representations (e.g., we are attending to *our* shared emotion, attitude, belief), or an awareness that we are attending to *our* mental state. As such, whereas collective attention to a common world limits doubt that the world is common knowledge, collective attention to a common mind mentally represents ‘our’ mind as common knowledge.

Collective attention to a common mind serves a critical purpose in human social coordination—it increases social cohesion, thus increasing the incentive to socially coordinate. A long line of psychological research attests to the importance of shared subjec-

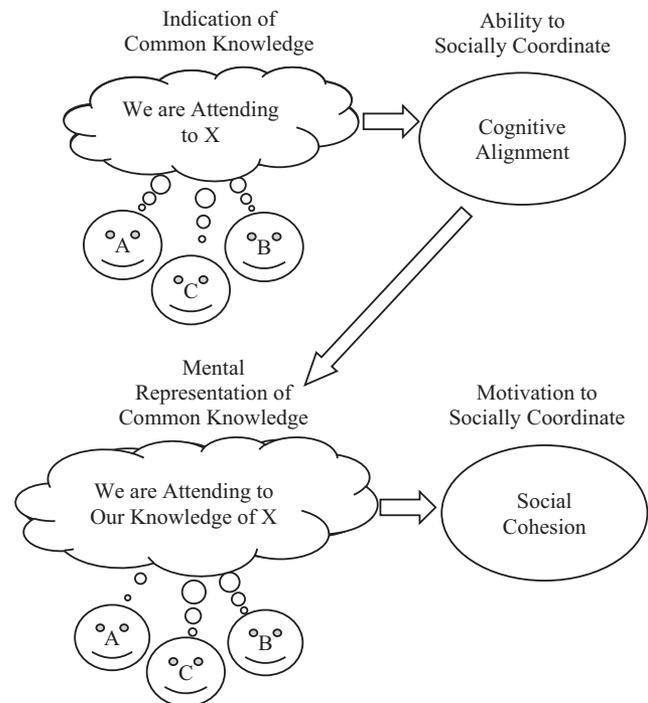


Figure 3. The theory of collective learning.

tive states for promoting affiliation (e.g., Bar-Tal, 2000; Echterhoff et al., 2009; Festinger, 1954; Hardin & Higgins, 1996; Pinel, Long, Landau, Alexander, & Pyszczynski, 2006), showing that shared subjective states increase feelings of affiliation and cooperation. That is, simply finding out that one’s subjective state is the same as that of another increases felt closeness toward the other (e.g., Pinel et al., 2006).

Such states have not been routinely connected to notions of common knowledge, however, where mutual awareness of such states functions to enhance social coordination. We posit that collective attention is the missing psychological ingredient that bridges shared subjective states (i.e., *we think X*) with notions of common knowledge (i.e., *we are attending to the fact that we feel, value, believe X*). If this is correct, then collective attention to shared subjective states should produce particularly strong affiliative responses. Indeed, research on I-sharing, or experiencing the same in-the-moment subjective experience as another person, suggests this is the case.

Participants in I-sharing experiments find out, synchronously, whether they have the same subjective response to a stimulus (e.g., both laugh) or have a different subjective response (e.g., one laughs, the other does not). Across studies, whether responding to nonsensical celebrity pairings, or inkblots, similarity in subjective responses results in greater liking of and generosity toward partners (see Pinel, 2018 for a review).

Simultaneous coexperience of a fleeting subjective similarity increases affiliation and cooperation, even in the face of long-standing objective differences in self-concepts, social identities, values, and beliefs (Pinel & Long, 2012; Pinel, Long, & Huneke, 2015). Collective attention to shared dysphoric experiences may be particularly motivating of extreme cooperation, where members

are willing to sacrifice their lives for the group's wellbeing (Whitehouse et al., 2017). This may be a product of a general human tendency to be more reactive to losses as compared with equivalent gains (Kahneman & Tversky, 1979). In collective attention terms, people like one another more when their shared subjective state is under *our* attention (e.g., *we* are attending to *our* pain).

Collective attention to common subjective knowledge may also increase collective identity (Turner, 1999)—wherein the common emotions, evaluations, and beliefs *under collective attention* constitute the novel contents of the collective identity, defining the social norms within its bounds. The formation of a stronger collective identity can facilitate group coordination even when it is individually costly, because it both signals which coordination strategy is known to all and motivates the coattendants to choose a strategy in the best interest of the collective (as opposed to the individual). We explore these ideas further when we discuss the implications of collective learning theory for collective identities, social norms, and strategic decision making (see the Implications for Collective Identity, Social Norms, and Strategic Cooperation section).

Collective attention is also likely to be a key feature of ritual psychology (Hobson, Schroeder, Risen, Xygalatas, & Inzlicht, 2018). By providing shared emotional experiences under collective attention, public rituals generate social cohesion that precedes social coordination (e.g., a pep rally before a football game; Chwe, 2001). Across cultures, marriage is typically a collectively witnessed ritual, often euphoric, that facilitates alliances between kin groups (Fox, 1983). In a similar vein, acting in unison, or synchronously, may increase affiliation (Hove & Risen, 2009) because it evokes collective attention on a common subjective state.

One may notice that social cohesion is not only an outcome of collective attention to common mental states, but is also constitutive of collective attention itself, given that collective attention requires a certain level of social connection to form a collective attending agent in the first place. Although this is indeed the case, there is an important difference between the experience of social connection that precedes the emergence of a collective agent and the experience of social connection through the collective agent's attention to common mental states. It is only in the latter case that the *target of attention* is the social connection itself (i.e., common mind). When collective attention is mentally represented, it is not itself the object of attention, serving instead as the perspectival background. However, when a collective subjective state becomes the target of collective attention, social cohesion is foregrounded.

Relatedly, because collective attention to common minds increases social cohesion, it also increases the strength of any subsequent collective attention. This increase in collective attention yields further cognitive prioritization of the collective mind, forming a positive feedback loop that may lead to overwhelming social emotion and social connection. Such cycles can be prominent in collectively witnessed rituals, wherein the crowd's attention is directed toward its own collective mental state. Of course, such cycles can also work in the opposite direction, when subjective reactions under collective attention differ, the collective attention itself may come under question.

In sum, whereas collective attention to the world increases knowledge alignment, and thus gives coattendants *the ability* to socially coordinate, collective attention to a common subjective state increases affiliation, and thus gives coattendants *the motiva-*

tion to socially coordinate. Put differently, whereas collective attention to objects is a solution to the epistemological or knowledge hurdle in social coordination (i.e., how can we coordinate?), collective attention to common minds is a solution to the incentive or motivational hurdle in social coordination (i.e., why should we coordinate?). A mental representation of common knowledge is not simply epistemological in nature, but can also be motivational, as it foregrounds a collective mind and thereby creates a psychological bond among individuals.

Together, collective attention to the objective world (indicating common knowledge) and shared subjective states (mentally representing common knowledge) facilitate the ability and motivation to think in groups, helping people to communicate, remember, and problem-solve interdependently.

Collective Attention and Cognitive Collaboration

We discuss how collective attention facilitates the emergence of common knowledge in three arenas of cognitive collaboration—communicating, remembering, and problem-solving together. As collective learning theory describes, collective attention encourages both the epistemological and motivational bases of cognitive collaboration.

Communicating

Collective attention facilitates communication because it signals that information will be communicated (i.e., serve as the foreground of a discussion), and understood by the self and by others (i.e., serve as the background of a discussion). Collective attention can also motivate communication when common subjective states become the object of collective awareness.

People “talk about the weather” because everyone has something to recall and contribute. Research on shared information bias shows that group discussions are dominated by what is known by multiple people (i.e., shared information), rather than what is known by singular individuals (Stasser & Titus, 2003). One explanation for shared information bias is simple mathematical probability: The more widespread a piece of information is across minds, the higher the probability is that the information will be recalled by at least one of those minds, leading to a greater chance of it being discussed (Bentley, Ormerod, & Shennan, 2011; Reali & Griffiths, 2010; Stasser, Taylor, & Hanna, 1989). Moreover, a piece of information that is mentioned in conversation is more likely to be subsequently rementioned, rather than to be ignored by others (Larson, Christensen, Abbott, & Franz, 1996; Stasser & Titus, 1987). As such, a socially shared piece of information is more likely to serve as the foreground of a conversation.

Individuals often have an inkling about what is socially shared in a specific cultural milieu and may start conversations accordingly. Consequently, however, collective attention may be critical in identifying socially shared information that is specific to a given social interaction, and hence what will be discussed. It follows that the cognitive prioritization of information experienced under collective attention will facilitate communication.

Collective attention also increases mutual understanding by establishing a common background for interaction. Common knowledge during a conversation is in constant flux, as the knowledge shared among participants in a conversation changes with the

ongoing flow of information (Clark, 1985). Maintaining common knowledge during the conversation allows the discussants to understand one another (Clark, 1985; Krauss & Fussell, 1990; Mead, 1934). Common knowledge of a lightning strike, for example, could arise in several ways. Clark (1985) argued that people are continuously ascertaining and maintaining common knowledge through speech acts. For instance, before saying “that was beautiful!” you may have asked your partner, “did you see that lightning?” so as to establish lightning as the commonly known reference. However, it may be that the speech act itself evokes a psychological state of collective attention that signals that the lightning strike is the object of common reference. Indeed, other factors that are used to establish common knowledge—pointing to an object in the physical environment (Clark & Marshall, 1981), or beliefs about shared group membership of the discussants (Fussell & Krauss, 1992)—may also evoke the psychological state of collective attention and thereby reduce doubt about the existence of common knowledge.

During communication, the existence of shared subjective states can become the focus of collective attention. Indeed, it is possible that the experience of understanding and being understood in a social interaction is often the experience of a common mental state from a collective point of view. In such cases, collective attention to collective mental states not only motivates further interaction, it motivates pursuit of those social interactions wherein the experience of mutual understanding (i.e., common mind) is its own reward. Intriguingly, our analysis implies that everyday communication may involve the formation of collective agents.

Finally, prioritizing the same collectively attended information at the same time allows both interaction partners to better anticipate future verbal and nonverbal behavior. For instance, as two people collectively attend to the fact that it is starting to rain, one can suggest they both go inside, anticipating the other’s request. In addition, anticipating that offer, the second person may glance at the door to indicate agreement before the first even speaks. However, if one only attends to the fact that it is raining after the other has, both lose such anticipatory capacities.

Remembering

What does it mean to remember together? Scholars of collective memory often focus on how people coinfluence each other’s memories of an event (Loftus, 1993; Roediger, Meade, & Bergman, 2001). Understanding social influences on individual memory (and their implications in aggregate for what is discussed in the group) is an important research goal (e.g., Hirst, Yamashiro, & Coman, 2018). However, the focus of such research has been the accuracy and breadth of *individual* memory (and implications of such for what is remembered in the group). Here we focus on the formation and function of memories that do not merely reside in any one individual, but are distributed among them. In this vein, Wegner (1987) argued that groups of people form and maintain transactive memory systems, where different individuals serve as experts in distinct knowledge domains. This allows for a group knowledge store that is far greater than any one individual can remember (Sparrow, Liu, & Wegner, 2011), conferring an adaptive benefit to a group of individuals that can participate in, and draw from, such group memory (Henrich & Broesch, 2011).

In a transactive memory system, it is important that group members know *who knows what* (Wegner, 1987). As Wegner (1987) makes clear, “One person has access to information in another’s memory by virtue of knowing that the other person is a location for an item with a certain label” (p. 190). That is, the access to the web of specialized expertise is often dependent upon knowledge of where that expertise is located, and what that expertise is called. In other words, although the expertise itself is compartmentalized, expertise domains and their distribution may be commonly known to those who participate in a transactive memory system. This is especially true of transactive memory systems in small, ad hoc groups that do not have an established repository of domain locations and labels such as a central directory, or a person tasked with knowing who knows what.

Critically, information about who knows what may be subject to change—the locations and labels of expertise shifting rapidly. Specifically, working groups that face a rapidly shifting informational landscape (e.g., emergency surgery teams) need to continuously update knowledge of their respective knowledge domains. Doubt about whether a group member knows about their novel domain of responsibility impairs trust of, and therefore reliance on, transactive memory systems. Collective attention to the changes in the transactive memory system leave little doubt as to whether others know about the change. For instance, in a surgery team that has high turnover in personnel, collective attention to personnel changes serves to provide critical updates to the transactive memory system of the team. Indeed, the World Health Organization’s surgical safety checklist in fact mandates that medical personnel introduce themselves and their roles to the team at the beginning of a surgery, *as well as* when they join an ongoing surgery (Woodman & Walker, 2016). Notably, the surgery team may also encounter novel domains of concern, such as internal bleeding. Collective attention to the concern as well as to who is responsible for it (via public announcement) indicates the creation of novel common knowledge, thus further growing the transactive memory system.

Moreover, whereas participation in transactive memory systems is seen as a means to achieve a greater store of expertise, common knowledge of the transactive system itself may also be its own reward. That is, collective experiences of locations and labels *as* common mental states increase social cohesion—giving group members a feeling of being a commonly known *part* of a commonly known *whole*.

Problem-Solving

Are several minds better at problem-solving than one? Much of 20th century cognitive science would suggest that they are worse—subject to groupthink (Janis, 1972) and extreme decision-making (Stoner, 1968). Other evidence, however, shows that groups generally outperform individuals on a wide range of problems (Hastie, 1986; Kerr & Tindale, 2004; Levine & Moreland, 1998). Indeed, groups outperform not only average individual performance, but also the best individual performance (Krause, Ruxton, & Krause, 2010; Laughlin, Hatch, Silver, & Boh, 2006), especially on difficult problems that involve abstraction (Hill, 1982). If groups of collaborators are able to out-perform even their best individual experts, then there must be more to the collective process than just learning from those experts. It is the combined

preferences, skills, and insights of group members that inform group-level deliberation and cognition, resulting in superior performance.

There is some evidence suggesting that common knowledge is critical to group problem-solving. Studies show that the best-performing groups are not necessarily composed of the best-performing individuals (Woolley, Aggarwal, & Malone, 2015). Rather, the best performing teams have more inclusive communication patterns, and greater mutual understanding among their team members (Engel, Woolley, Jing, Chabris, & Malone, 2014; Woolley, Chabris, Pentland, Hashmi, & Malone, 2010).

If collective attention indicates and mentally represents common knowledge, it both limits doubt about what everyone knows and enhances motivation to socially coordinate. For instance, knowing we attended to a lightning strike together is more likely to spur conversation about what we saw. Better memory for what each of us experienced as collectively attended allows a broader and more in-depth conversation about what happened. One of us may have noticed a flame near the lightning strike, whereas the other one may have noticed a spark, similar to the one produced by the hitting of two rocks. We can contribute our unique perspectives and weave a joint recollection of the event. Had we developed a transactive memory system prior to the observation of the lightning strike, we could more surely expect distinct domains of expertise to inform the subsequent conversation. In the end, the cognitive collaboration enabled by collective attention to the lightning strike may enable the idea that the spark was the cause of the fire—an idea born at the intersection of distinct perspectives that were able to inform one another due the indication and representation of common knowledge.

Implications for Collective Identity, Social Norms, and Strategic Cooperation

The notion that collective attention can both indicate and mentally represent common knowledge (Collective Learning Theory) was developed to further our understanding of the psychological capacities that allow group members to pool their cognitive resources in the acts of communicating, remembering, and problem-solving. However, psychological indication and representation of common knowledge has implications beyond cognitive collaboration. Here, we discuss the implications of collective learning for three areas of inquiry: collective identity, social norms, and strategic cooperation.

Collective Identity

In William James' (1890/1991) classic formulation, the objective self (Me) includes an individual's self-representations, whereas the subjective self (I) is the locus of personal attention and experience from one moment to another (the stream of consciousness). Expanding this to the collective level, the plural self can similarly be divided into an objective component (Us) that includes one's social identity representations (stereotypes and social category knowledge; Turner et al., 1987), and a subjective component (We) that is the locus of collective attention and experience.

An interesting implication of this analogy reveals the impact collective identity can have on the state of collective attention. In

particular, just as the contours of one's personal identity (Me) shape the experiential aspects of the self (I) via identity-based sensemaking processes (Watson, 2009), so too can the contours of one's collective identity (Us) shape the experiential aspects of the collective self (We). As the salience of one's various social identities changes from one situation to another (Hogg & Turner, 1987), the boundaries and experience of collective attention may change as well. In particular, the state of collective attention will be anchored in the inferred attentional state of whichever collective self is salient in the moment. The more knowledge an individual has about the norms of his or her social group (i.e., more detailed social category representations), the more that the state of collective attention is likely to be influenced by normative factors that guide attentional allocation (Ramstead, Veissière, & Kir-mayer, 2016).

Just as collective identity can shape the targets of collective attention, collective attention can shape collective identity. When the target of collective attention (We) is collective identity itself (Us), collective identity structures, including their cognitive and affective contents, should loom larger in cognition, emotion, and action. Moreover, when collective attention is embedded within an extant collective identity (We, Americans, are attending), novel targets of collective attention (e.g., going to the moon) may become associated with that collective identity, constituting novel identity content. The implications are most interesting when novel targets of collective attention are shared subjective states. In such instances of collective attention (e.g., mass celebrations after a revolution), the affiliative bonds that define and unite a collective may undergo drastic change (e.g., the emergence of a novel unifying ideology). In all cases, the strength of collective attention and its targets are likely to define the contours and contents of newly emergent collective identities.

Social Norms

Lewis' (1969) famous formulation of common knowledge regards social norms, what he termed social conventions, as rational choice equilibria. That is, social norms are common knowledge, representing critical guideposts for social coordination within groups. Following Lewis' account, a theory that posits a psychological account of common knowledge should also shed light on our understanding of the psychology of social norms.

At the root of a social norm is some sense of behavioral consensus. Individuals do not deviate from that consensus because that would cause social confusion, or perhaps public disapproval and punishment. For instance, in the United States, placing forks to the right of the plate would lead to confusion among one's guests; however, driving on the left side of the road would lead to institutional punishment. In both cases, people rarely deviate from social norms because once social equilibrium is reached, individual deviation is unprofitable. However, this social equilibrium account of social norms does not offer a psychological explanation of why and how social norms change. That is, given that deviation by any one individual is ill-advised, what is the psychological impetus to change from one social equilibrium to another?

To move to a new behavioral equilibrium requires some assurance that one will not be alone. As we have argued, collective attention is a psychological indicator that a novel behavior is common knowledge. That is, if *we attend to the behavior*, constit-

uent group members have little reason to doubt that each is aware of each other's awareness of the behavior. Although the psychological indication that a novel behavior is common knowledge does not mean it will be behaviorally adopted, it is an important step in the process, because it dispels doubt as to the *possibility* of its widespread adoption. That is, novel behaviors encountered in psychological states of collective attention have a distinct advantage in becoming novel social equilibria over novel behaviors that are not encountered under collective attention. Accordingly, Shteynberg and Apfelbaum (2013) found that collectively attended behaviors are more likely to be behaviorally adopted and enacted.

Thus far, we have outlined the implications of collective attention for the emergence of novel social behavior (descriptive norms; see Shteynberg, 2014). Another aspect of social norms is that they are often moralized, and serve as injunctions (Cialdini, Reno, & Kallgren, 1990)—transgressions of which are often punished by other people or social institutions (Morris, Hong, Chiu, & Liu, 2015). For an individual, a move to a novel injunctive norm is especially risky, because one may be judged harshly if other group members do not accept the new moral standard.

Critically, injunctive norms are inherently metacognitive (Morris et al., 2015), because they are experienced as moral judgments located in peoples' minds. From a collective learning perspective, collective attention to a collective mind is a metacognitive state that is fertile ground for the emergence of a novel injunctive norm. First, when we see that we are happy, sad, or indifferent, at some novel turn of events, the group's specific mind state is being collectively attended. In such situations, there is no reason to doubt that others have the same metacognitive state as the self. Second, although collective subjective states are not necessarily moralized judgments, people want their moralized judgments to be collective subjective states. Indeed, the need to universalize one's moral judgments distinguishes them from other subjective attitudes (Skitka, Bauman, & Sargis, 2005). As such, although collective attention to a collective mind does not necessarily constitute a novel moral judgment, it is fertile ground for its development, since collective subjective consensus is a key aspect of a moralized norm.

Strategic Cooperation

Common knowledge is central to understanding strategic cooperation (Lewis, 1969; Schelling, 1960). In some coordination games, the would-be cooperators' only obstacle to cooperation is one of social epistemology—does the other player know what I know . . . and so on. For instance, in the stag hunt game, the greatest payoff is attained through cooperation. In this game, as long as there is common knowledge about that payoff structure, a rational actor should choose to cooperate. Indeed, Thomas et al. (2014) found that when the stag hunt's payoff structure is communicated via a public speaker, presumably indicating common knowledge, cooperation was significantly higher than when the payoff structure was communicated in a nonpublic manner. From a collective learning perspective, collective attention to a payoff structure limits doubt about common knowledge and therefore should be sufficient to increase cooperation when cooperation is indeed mutually beneficial. Public announcement over a loudspeaker may suffice if it is sufficient to engender a state of collective attention, and may fail if it does not. Critically, as the

reviewed experiments suggest (section 3), synchronous coattention with ingroup others is most conducive to establishing collective attention and hence reducing doubt that the payoff structure is common knowledge.

The path to cooperation is harder for rational actors in a prisoner's dilemma game, where the best payoff lies in defecting while the other cooperates. In this game, it is more rational to defect, even when the payoff structure is commonly known. From a collective learning perspective, cooperation in the prisoner's dilemma is not a matter of payoff knowledge, but rather of payoff transformation. For instance, when the strategic question is transformed from "what is the best strategy for me?" to "what is the best strategy for us?", cooperation in a prisoner's dilemma game becomes more rational than defection. From a collective learning perspective, this is likely to happen when collective attention foregrounds a common subjective state (see the From Collective Attention to Common Knowledge section), yielding strong social cohesion. Moreover, when the collective mindset is experienced under collective attention, there is no reason to doubt that the other player has the same collective mindset. This is also perhaps why actual or imagined interaction (Misyak & Chater, 2014; Misyak, Melkonyan, Zeitoun, & Chater, 2014), which engages collective learning processes (see the Collective Attention and Cognitive Collaboration section), increases strategic cooperation.

From the collective learning perspective, public announcement over a loudspeaker is unlikely to engender collective attention to collective mind unless coattendants receive further information about their intersubjective state. In all, strategic decision making in games where cooperation is beneficial, and/or carries substantial risk, may depend on the psychological processes of collective learning, rather than the specific technological modes through which the interaction takes place.

Conclusion

We have argued that collective attention to information signals that the information is becoming common knowledge—a distinctive form of knowledge that enables cognitive collaboration through communication, group memory, and collective problem-solving. Whereas collective attention to the world enables knowledge alignment, collective attention to common mental states increases social cohesion, and together they facilitate the application of common knowledge states among collaborators. The collective attention process renders cognitive collaboration more likely and fruitful, leveraging the power and knowledge of multiple minds to produce superior cultural innovations.

The ability to think together is particularly important when facing challenges that overwhelm an individual mind's capacity to resolve. Such challenges may arise during periods of rapid environmental change, when imitation of past behaviors ceases to be adaptive (Mesoudi, 2008; Rendell et al., 2011). By enabling common knowledge, the psychological state of collective attention allows individuals in interaction to devise adaptive solutions that are superior to those of the smartest individuals. Learning collectively helps groups to achieve what no one individual can.

Whereas we have focused on the importance of collective attention to learning, it is also important in teaching. Knowing how to instruct requires tracking the common knowledge between oneself and the learner. As Vygotsky (1978) observed, the teacher must instruct in the

zone of proximal development of the learner, if the learner is to assimilate the new knowledge. By directing the flow of information under collective attention during instruction, the teacher slowly scaffolds the complexity of what can be known together. Failure to do so may manifest in the student or teacher's realization that the presented information is seen differently by the other party, and that mutual understanding is out of current reach. Resumption of collective attention can be accomplished by student questions, or by the teacher's reformulation of presented information.

Learning from others and teaching are, of course, fundamentally communicative activities. In agreement, some models of cultural transmission (Kashima, Woolcock, & Kashima, 2000) hold that learning happens in concrete episodes of social interaction that require mutual understanding (Kashima, Klein, & Clark, 2007). In the same vein, Chiu, Leung, and Kwan (2007) argue that language is most likely to shape mind (Post-Worfian Hypothesis) when it is used in dyadic communication wherein common knowledge is manifest. By signaling and enabling common knowledge, collective attention is critical to the accumulation of cultural knowledge through the intertwined acts (Legare, 2017) of learning and teaching.

Ever since the advent of mass media, the scale of common knowledge can reach many orders of magnitude larger than in small-scale societies (e.g., 3.4 billion watched the World Cup in 2018). Moreover, social media technologies not only prioritize popularity in their algorithms, they also present users with metrics of how many others are coaware of the information. This encourages the possibility of a psychological state of collective attention on a mass scale that may or may not translate into cognitive collaboration. At present, cognitive collaboration is largely limited to institutionally bound groups of individuals pursuing a common goal. As communication and coordination technologies develop, however, it is possible that the scale of cognitive collaboration may expand dramatically.

Collaboration with others plays a pivotal role in human cognition and human cultural life (e.g., Rogoff, 1998; Tomasello, 2019; Vygotsky, 1978). The theory of collective learning describes how the capacity to mentally represent objects, events, and minds as targets of first-person plural attention facilitates cognitive collaboration in groups. Not armed with comparative evidence, we are unable to say whether collective attention is unique to humans. But given the unique ubiquity and breadth of human cognitive collaboration, collective attention may be uniquely human, if not in its existence, then in its frequency and scale.

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