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Perceiving mental states

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ABSTRACT

This paper argues that our awareness of the mental states of other agents is often perceptual in character. It draws partly on recent experimental findings concerning perception of animacy and intentionality. But it also emphasizes the unencapsulated nature of perception generally, and argues that concepts (including mental-state concepts) can be bound into the contents of conscious perception. One of the main arguments used in support of this conclusion draws on recent work concerning the nature and contents of working memory.

1. Introduction

Phenomenologically, our awareness of the mental states of other people can often seem immediate. It seems that we can just *see* someone's anger or fear, and our impression that a triangle in an animation display is chasing (trying to catch) a circle can seemingly be part of our perception of the event, not inferred in thought thereafter. Likewise, when someone reaches toward a glass of water we see her as *intending* to pick it up, and when someone is fumbling with a key in a lock we see her as *trying* to open it. Moreover, when people speak, we often seem to *hear* the intent behind their utterances (as joking, ironic, or whatever). And so when someone says to me, "I think the Democrats will keep the Presidency next time", I might hear her as *judging* or *believing* that they will. Or if someone stops me in the street and asks, "Can you tell me the way to the church?", I might hear her as *wanting* to know the church's location. These phenomenological facts don't resolve the issue, of course. Introspection can perhaps tell us of the coincidence in *time* between our conscious perception of an action and our awareness of the mental state that causes the action (although see Dennett & Kinsbourne, 1992). But it cannot tell us whether that awareness is a component *part* of the perceptual state or not.

In fact, introspection cannot be used to determine whether there exists just one mental event, which is perceptual in nature, and which contains a representation of someone else's mental state, or whether two distinct events co-occur: a conscious perceiving of the action, and a conscious judgment about the mental state underlying the perceived action. Sometimes introspection can determine that a judgment occurs *separately*, of course—if there is a noticeable time-lag between one's perception of the event and one's awareness of the underlying mental state, for example, or if one's judgment is expressed in inner speech or in some other sensory-like event that is distinct from the perceptual state itself. But if one assumes that judgments can also occur consciously in the absence of such "sensory clothing", then there need be nothing to signal the separation of those judgments from the perceptual states that ground them. (In Section 5 we will return to consider whether or not this assumption *should* be allowed.) One will merely be aware of a perception of someone's actions and

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be aware of a judgment about her mental state, without anything to indicate whether or not the latter forms a constitutive *part* of the former.

What seems undeniable is that judgments about people's mental states can occur consciously (at least in the *access*-conscious sense; see Block, 1995),[1] and that they can do so in the absence of inner speech or any other such medium of representation. In fact one's "seeing" or "hearing" someone as possessing a mental state can have all of the hallmarks of a globally broadcast access-conscious event. In such cases one's awareness of someone's mental state can give rise to long-term memories, can issue in affective reactions, can guide one's verbal report of what one sees or hears, and can immediately influence one's planning and decision making. A lot may then turn on the question whether it is possible for amodal conceptual judgments of this sort to be conscious *without* being a part of some globally broadcast perceptual or sensory-like state. If they cannot, then it will follow that the mentalizing judgment in such cases must be a part of the perceptual state itself. We will return to this issue in Section 5.

The phenomenology of perceiving mental states has been taken at face value and emphasized especially by philosophers critical of both theory-theory and simulationist approaches to our understanding of other minds (Gallagher, 2001; Hutto, 2004). But the grounds for these criticisms are puzzling. Even if the perceptual character of our awareness of others' mental states in such cases is granted, it is far from clear why theory-theorists, in particular, should have any problem. For why cannot theory-theorists endorse the perceptibility of at least some types of mental state? Indeed, one might think that *any* adequate account of our perception of mental states (assuming that the latter is real) would need to appeal to a set of tacit inferences underlying such perceptions, which might then qualify as a form of theory-theory.

Admittedly, theory-theorists often introduce their work by emphasizing that mental states are abstract and imperceptible, generally by way of motivating the need for theory (Gopnik & Wellman, 1992). But one thing this might mean is just that mental properties cannot be *simply* seen (Dretske, 1979). That is, they cannot be seen independently of concepts and acquired knowledge of the world. (In this sense, the property of being a laptop computer cannot be simply seen, either.) Moreover, even if such statements by theory-theorists *are* intended to rule out perception of mental states altogether, it is far from clear that there is anything about theory-theory, as such, that requires such a stance. It may be that the statements in question are an optional extra, and that theory-theorists can just as easily accept that mental states are perceptible.

Indeed, one can ask: How *else* could one account for perception of mental states *except* through commitment to some form of tacit theory? How do writers such as Gallagher (2001) and Hutto (2004) think they can claim mental states to be perceptible without being led straight to a form of theory-theory? Gallagher (2001) is apt to stress that mental states like emotions and goals are *directly expressed* in bodily actions. So they can be perceived as directly as those actions themselves. This is implausible, however. There are no one-to-one correspondences between mental states and behavior. The actions and facial expressions that manifest any given mental state are always context-sensitive, and vary depending on the agent's other mental states and circumstances. As Smith (2010) points out, however, the true source of the belief that mental states can be perceived without relying on tacit theory may lie in the influence of Husserl (1973), specifically his account of what makes the unseen components of objects nevertheless *co-present* in perception. These views find their contemporary development in *enactivist* accounts of perceptual content (Noë, 2004).

According to enactivists, the contents of our perceptual states are constituted by a body of sensorimotor knowledge, or *know how*. Seeing a book as having a back as well as a front, for example, or seeing a complete cat as moving along behind a slotted fence, consists in one's ability to anticipate how one's perceptual experience would change if one were to pick up the book, or walk around the fence. This meshes nicely with the stress that Gallagher (2001) and Hutto (2004) place on *second-person* engagement with other people as being the fundamental mode of mindreading. When one is interacting with others, one is continually forming expectations about what will happen next, about how the other person will react if one responds in one way rather than another, and so on. Perception of the other person's mental states can then be said to be constituted by such sensorimotor knowledge, without needing to be grounded in any sort of tacit theory.

The arguments offered in support of enactivism persistently conflate *cause* and *constitution*, however (Block, 2005). At best they establish that perceptual contents both give rise to, and are influenced by, sensorimotor knowledge; they do not establish that they are constituted by such knowledge. For instance, one prominent argument used by Noë (2004) is that the perceptual contents of people wearing spatially-inverting lenses will right themselves after a few days, *but only if the subject is allowed to move around and act* while wearing them. What this shows is that visual contents are causally influenced by feedback loops linking perception, planning, and action; it does not begin to show that they are constituted by such loops. Likewise, although one knows what a nickel that one sees from an angle will look like when picked up, this need not *constitute* one's seeing it as round. Rather, seeing it (representing it) *as* a round nickel enables one to *predict* the nature of one's experience when viewing it from other angles.

In any case, however, even enactivism cannot obviate the need for tacit theory. Suppose we grant that one can have sensorimotor know-how with respect to other people, especially when interacting with those people face-to-face. And suppose we grant that this can constitute perception of the mental states of others. Still we need to explain how these sensorimotor expectancies get caused by the details of the behavior of the other person in a given context. We need to explain why someone will, in one context, anticipate one action, yet in a subtly different context, or with subtle differences in the other's

[1] My own view is that while concepts—including mental-state concepts—can be component parts of access-conscious perceptual states, they never make a constitutive contribution to the phenomenal properties of such states (Veillet & Carruthers, 2011). This is because only nonconceptual content gives rise to the so-called "hard problems" that are characteristic of phenomenal consciousness.

behavior, will anticipate something else. We have no idea how to explain the causal processes involved except by appealing to something amounting to a tacit *theory*, I suggest.

My goal here is not to provide a critique of enactivist theories of perception, however. Rather, assuming the correctness of some or other form of classical representationalist account, my goal is to argue that the mental states of other people are often represented *in the content of perception*. But I will also suggest that this conclusion is consistent with the main forms of theory-theory of our mindreading abilities.

One final set of clarificatory comments is necessary before we begin the main discussion. This concerns the varied ways in which one might draw a distinction between perception, on the one hand, and cognition, on the other. In asking whether mental states can be perceived, there are a number of things one could mean. One is whether awareness of another's mental states is ever phenomenally conscious, or makes a constitutive contribution to the phenomenal properties of one's experience. In my view this is not a helpful question to ask, since phenomenal differences are heavily dependent on introspection, and because introspection is insensitive to the distinction between cause and constitution, as I pointed out above.[2] What one *can* ask, however—and this will form our main topic—is whether one's awareness of another's mental states is ever a constitutive part of a globally broadcast, access-conscious, perceptual state. This question is tractable in a way that the corresponding question about phenomenal consciousness is not.

There are two other things one might mean in asking whether perceptual states are perceptible, however. One is whether awareness of another's mental states is ever *encapsulated* from the remainder of one's beliefs and goals. This way of thinking of the perception / cognition boundary presumes that there is a stage in visual processing—sometimes called "early vision"—that is beyond any direct influence from one's goals and background knowledge. As we will see in Section 3, however, it is doubtful whether there is any such stage. But another thing one might mean to ask is whether awareness of another's mental states can ever be nonconceptual rather than conceptual, which amounts to asking whether mental states can ever be *simply* perceived (Dretske, 1979). This way of thinking of the contrast between perception and cognition is legitimate, and the question it raises is an interesting one. (This will be addressed in Section 2.) Indeed, the question about the components of globally broadcast experience raised earlier presupposes the same distinction. For if one asks what makes something an access-conscious *experience* or *perception*, one should reply that it is a state that is at least partly comprised of fine-grained nonconceptual representations.

The main question to be addressed in this paper is whether awareness of the mental states of other people is ever a component part of an access-conscious perceptual state (which is also partly comprised of nonconceptual representations). We begin in Section 2, however, with some discussion of the question whether there can be access-conscious awareness of the mental states of other people that is wholly nonconceptual in nature.

2. Perception of animacy

It has long been known that people will—under the right conditions—spontaneously report the movements of simple geometric shapes using mentalistic language (Heider & Simmel, 1944). They will say that the triangle is chasing and bullying the square, for example, while the circle is trying to protect the square. Indeed, it is not just one's reports that are spontaneous, but it seems one spontaneously *sees* the movements of the shapes in such terms. At the very least we can say that conscious mentalizing judgments in such cases co-occur with one's perceptions, even if they aren't constitutively parts of those perceptions.

Such phenomena have been systematically investigated using nonverbal as well as verbal measures (Gao, McCarthy, & Scholl, 2010). It turns out that perceptions of animacy are really quite robust across individuals, while being highly sensitive to small variations in the stimuli. The same set of random motions of a group of triangles, for example, will be perceived as a "wolf-pack" hunting a target when all the triangles remain oriented toward the target, while being perceived as just triangles-in-motion when those shapes are re-oriented by 90 degrees. Moreover, it turns out that people are incapable of turning off their impression of animacy, even when it interferes with their performance of a task, and even when they are fully informed about the nature of the stimuli.

Scholl and Gao (2013) review these and other findings while making the case that perceptions of goal-directedness are genuinely perceptual in nature. They point out that the effects seem to be universal to human beings as such (Barrett, Todd, Miller, & Blythe, 2005), with the exception of people with autistic spectrum disorder (Abell, Happé, & Frith, 2000; Klin, 2000; Rutherford, Pennington, & Rogers, 2006). People can no more prevent themselves from seeing certain movements as animated by specific goals than they can prevent themselves from seeing colors and shapes when they open their eyes. Moreover, distinctively visual areas of the brain seem to be implicated in animacy perception, and such perceptions interact with attentional processes in just the way one would expect of phenomena that are genuinely visual in nature.

Such arguments are not probative, of course. At best they establish that there is a certain class of judgments that are *immediately caused* by perception, employing categories that are universal to all humans. Compare perceptions of fire. One does not *choose* to see a burning bush as being on fire, and one cannot easily prevent oneself from doing so. Moreover, fire is attention-grabbing in the same way that chasing is. And the same is likely to be true of all human beings as such, with the exception of those who have suffered neurological damage. It requires an argument of a different sort to

[2] In addition, I think that *no* concepts or conceptual judgments *ever* make a constitutive contribution to the phenomenal properties of one's experience (Veillet & Carruthers, 2011).

establish that animacy and on-fire-ness are genuinely *components* of our perceptions, rather than distinct judgments that are mandatorily caused by our perceptions.

An intriguing question raised by these data, however, is whether they might involve *nonconceptual* representations of goal-directedness as such. If so, then this would warrant one in concluding that perceptions of animacy are genuinely perceptual in character, provided one thinks that the perception/cognition divide either reduces to, or co-occurs with, the nonconceptual/conceptual one.[3] One can have a more-or-less vivid impression of the animated nature of the shapes in a display, of course. Is this a matter of one perceptually representing *degrees of animacy*, much as one's more-or-less vivid impression of the redness of a tomato can reflect one's nonconceptual representation of its degree of redness? Likewise, one can have a more-or-less vivid impression of anger in someone's face and behavior, for example. Is this a matter of one nonconceptually representing their degree of anger, just as one nonconceptually represents a degree of redness?

It may be that these two examples are different, and should not be assimilated. For anger, like other emotions, admits of degrees. One can be more-or-less angry, more-or-less fearful, and so on. But it is not clear that animacy admits of degrees. One's movements are either animated by goals, or they are not. One can of course pursue a goal half-heartedly, or only some of the time; and one can waver between different goals. But in the wolf-pack experiments of Gao et al. (2010), participants perceived the results categorically when such variations were introduced. For instance, a "wolf" that frequently switched its pursuit between two different "sheep" wasn't seen as *partly chasing* each of them, but as switching between chasing one and then chasing the other. And this was true even when there was enough noise in the movements of the wolf that its target could be ambiguous. This suggests that one's more-or-less vivid impression of animacy is really a categorical perception of animacy in which one has more-or-less *confidence*, rather than a nonconceptual representation of the degree to which a mental state is present.

That leaves us with the examples of perception of emotion, however. And even if acting in pursuit of a goal doesn't admit of degrees, one's goals can be more or less strong, and this, too, can sometimes seemingly be perceived. (Think of someone looking *longingly* at a piece of chocolate cake versus looking at it with *mild interest*.) Are these cases in which one has a nonconceptual representation of the degree to which a mental state is present? While perceptions of anger and fear generally co-occur with a conceptual understanding of the nature of the mental states involved, it is possible that this need not always be the case. It may be that cues of anger have been channeled by evolution to guide behavior even in people or animals that lack the concept of anger. For instance, we know that emotional displays across species will tend to cause mirroring emotions in the observer (Hatfield, Cacioppo, & Rapson, 1994), suggesting that there is something about the perception of the display that is emotion-specific, even if nonconceptual.

There are a number of difficult issues here that are presently hard to resolve, however. One is the question of what it would take for a perceptual state to contain a nonconceptual representation of anger or fear. What would transform one's perception of the detailed, fine-grained, configuration of an angry face into a perception of anger as such, if not the addition of the concept anger? Would it be enough that the state should reliably cause a mirroring emotion in oneself? Or must one also be disposed to act appropriately in the light of the target agent's emotional state (in a way that isn't just expressive of one's own mirroring one)? And is this possible in a creature who lacks concepts of the various emotions? I don't currently see how one might settle such questions. But they surely open up important avenues for future research.

In any case, however, it seems plain that nonconceptual representations of mental states (if possible at all) will be restricted to only a few types of case. Perhaps one can nonconceptually represent others' emotions, and perhaps some of their basic desires, like hunger, or feelings like pain. Our topic in the sections that follow, in contrast, is the question whether one might be capable of perceiving mental states of all kinds, including beliefs. Can one literally *see* what someone is intending or wanting? And can one *hear* other people's beliefs or decisions when they speak, just as one's conscious experience suggests? These questions require us to examine the nature of categorical perception, or perception that involves concepts.

3. Concepts in perception

Vision scientists sometimes write, for simplicity, as if object-recognition occurs in two discrete stages: the first builds a nonconceptual representation of the thing's color, texture, and form; and then the second brings to bear conceptual templates on the results of the first phase to determine a best match. This would be consistent with a view that keeps nonconceptual perception sharply separate and encapsulated from concept-involving cognition. But increasingly it has been argued that perceptual processing is deeply interactive at many different levels simultaneously (Clark, 2013; Panichello, Cheung, & Bar, 2013; Rauss, Schwartz, & Pourtois, 2011; Vetter & Newen, 2014; Wyatt, Jilk, & O'Reilly, 2014). Indeed, many have claimed to show that concepts interact with visual processing at early (pre-attentive) stages, influencing the resulting perceptual contents and perceptual phenomenology.

Reviewing more than twenty years of behavioral and neurocognitive work, Kosslyn (1994) argues that object-recognition depends on back-and-forth processing involving both mid-level and higher-level visual areas, especially in cases where the input is ambiguous or degraded. Conceptual information is used to "query" the input at lower levels, seeking to provide a

[3] While writers such as McDowell (1994) have denied the existence of nonconceptual states, this is arguably not relevant for our purposes. For even McDowell allows a distinction between the concepts that figure in our thoughts and the fine-grained indexical judgments that he thinks constitute perception. That is all that I really need here.

best match to the input, and filling in details as needed. More recent work seems to vindicate this account. Wyatt, Jilk, and O'Reilly (2014), for example, review a range of results suggesting that feedback from inferotemporal conceptual areas begins to have an impact on processing in visual cortex as early as 100 ms following the onset of a stimulus, and significantly before top-down attention begins to have any effect (at around 200 ms after stimulus onset). Among the effects of this recurrent processing are thought to be a number of types of change at lower levels of visual representation, including the filling-in of missing portions of a figure that is partly occluded (or that is *assumed* at higher levels to be occluded, as with the illusory contours one sees in Kanizsa shapes).

In addition to these top-down effects from conceptual information in temporal cortex, Bar et al. (2006) argue that there are similar effects from swiftly-computed conceptual "gist" information represented in orbitofrontal cortex, again at quite early stages of processing. They suggest that low spatial-frequency information is transmitted rapidly to orbitofrontal cortex, where it activates a range of related concepts (e.g. UMBRELLA and MUSHROOM, when the stimulus approximates an upside-down semicircle with a projection underneath). These concepts are evaluated for emotional salience (Chaumon, Kveraga, Barrett, & Bar, 2013), and are projected back to mid-level as well as higher-level visual areas. Notably, stimulus-dependent activity in orbitofrontal cortex occurs some 50 ms *earlier* than it does in object-recognition areas of temporal cortex. Moreover, the effect is to set up phase synchrony in the neural activity in these areas and in visual cortex, suggesting meaningful interactions between them. In effect, the evidence suggests that top-down gist signals bias processing in both visual and temporal cortex by providing a set of hypotheses to be tested against the incoming data.

Moreover, it has long been known that concept-learning has an impact on perception (Goldstone, 1994; Goldstone, Lippa, & Shiffrin, 2001). Acquiring concepts that classify a set of arbitrary similar-seeming shapes into two distinct categories, for example, transforms the perceived similarity spaces among the shapes. Those that seemed similar before now seem distinctively different as a result of category acquisition. Until recently, however, it was unclear to what extent these effects reflect a late decision-like stage in processing, or whether sensory experience is altered by concepts in an online manner. But there is now considerable evidence of the latter.

Thierry, Athanasopoulos, Wiggett, Dering, and Kuipers (2009), for example, tested speakers of English and Greek on a simple task in which they had to detect the presence of a different shape (a square) in a sequence of briefly presented colored circles. Greek differs from English in having two distinct terms for blue: "ghalazio" for light blue and "ble" for dark blue. All participants watched a series of blue circles (in the experimental condition) on the lookout for an occasional blue square, or watched a series of green circles (in the control condition) on the lookout for a green square. The blue circles were either mostly light blue, with an occasional dark blue one inserted into the sequence, or were mostly dark blue with an occasional light blue circle. The experimenters recorded the participants' brain waves throughout. What they measured was the pulse of so-called "visual mismatch negativity" over visual cortex that occurs less than 200 ms following presentation of an oddball stimulus (e.g. a square following a series of circles). This is thought to reflect a pre-attentive and unconscious stage of visual processing, which occurs when an unexpected difference is detected in the course of one's experience.

All participants in this experiment showed a mismatch negativity response for all color contrasts. Among the English speakers there was no difference between their response to a light-green/dark-green contrast and their response to a light-blue/dark-blue contrast. Among Greek speakers, on the other hand, the negativity response to the latter contrast was significantly larger. This suggests that the two blues were seen as more unlike one another than the two greens. It seems that because Greek speakers have distinct *concepts* for light blue and dark blue, they see the two colors as more distinct. And they do so from quite early stages in visual processing, prior to the impact of attention or judgment.

Mo, Xu, Kay, and Tan (2011), too, looked at the visual mismatch negativity response (this time among native speakers of Mandarin), finding that it is greater for mismatches across categories. They arranged for the stimuli to be projected only to one hemisphere or the other, however. Interestingly, they were only able to find an effect of category differences among colors in the left (linguistic/conceptual) hemisphere. Witzel and Gegenfurtner (2011), in contrast, found category effects using similar paradigms in both hemispheres. It is unclear what explains this discrepancy (except that people are known to differ in the extent to which lexical and conceptual information is processed by the right hemisphere). The important finding for our purposes, however, is that categorical information can influence and facilitate color processing at quite early stages of visual analysis.

One possible explanation of such results is that concept acquisition permanently "warps" the processing that takes place in midlevel visual areas. This would be consistent with maintaining that in online tasks a sharp division is maintained between perception and cognition. However, Lupyan (2012) reviews a number of studies suggesting that the influence of cognition on perception is an online one, and can be eliminated in individual trials through simple manipulations. Consistent with the views of Kosslyn (1994), he argues that concepts and nonconceptual feature-representations interact in an online manner at early stages of visual processing, with the former exerting a causal influence on the latter.

Of course it would be possible to maintain, in the face of all this data, that although concepts *interact* with visual processing at quite early stages, perceptual and conceptual contents are nevertheless globally broadcast independently of one another. Although the data count strongly against any claimed independence of perception and cognition at the level of online perceptual processing, such independence can still be insisted on at the level of output. But such a view now seems quite unmotivated. Given that conceptual and nonconceptual representations interact so deeply and pervasively in perceptual processing, it makes more sense that both should be integrated into the results of that processing, and bound into object-files and event-files that incorporate both forms of representation.

Moreover, by supposing that concepts can be parts of conscious perception we can appeal to known mechanisms to explain how such concepts and perceptual judgments can become access-conscious. We now know a good deal about

how attentional signals directed at midlevel perceptual areas can boost some neural populations while suppressing others, resulting in the global broadcast of the information encoded in the former populations. (See Carruthers, 2015, for a recent review.) We also have well-developed theories of how the different properties of an object or event, processed in different regions of the brain, can be bound together into a single object-file or event-file (Kahneman & Triesman, 1984; Kahneman, Triesman, & Gibbs, 1992; Pylyshyn, 2003). All of this information is globally broadcast together as a result of targeted attention. If we suppose that concepts, too, can be bound into these files and globally broadcast along with them, then we can explain how perceptual judgments can become access-conscious by appealing to theories and mechanisms that we have antecedent reason to believe in. On the other hand, we know nothing about the supposed mechanisms that might result in the global broadcast of conceptual information alone. So our choice is between a theory that enables us to explain our target phenomenon and one that leaves us without any explanation. An inference to the best explanation then enables us to conclude that concepts are globally broadcast as component parts of perceptual states.

4. Seeing *as* and hearing *as* minded

I suggest, then, that when we consciously see something *as* an instance of a kind, the concept that represents that kind is bound into the object-file that nonconceptually represents its other properties, and is globally broadcast along with the latter.

It should be stressed that in order to see something *as* an instance of a kind it is not enough that one be entertaining a thought (even a thought that is seemingly conscious) of the kind while perceiving the thing in question. Rather, the two components need to be bound together in a single integrated representation, resulting from the back-and-forth processing that underlies object recognition. Examine the figure below, in the knowledge that the picture contains, somehow, a representation of a Dalmatian dog. If you have not seen this picture before, it is likely that it will take you a little while to see a subset of the dark splotches *as* a Dalmatian. In the intervening time you are consciously experiencing the dots, of course, while at the same time entertaining the concept DALMATIAN. But it is only when recognition occurs that the subset of dots configures into a familiar Dalmatian shape, with all the illusory contours filled in. A plausible interpretation is that binding the concept DALMATIAN into your perception of the dots is necessary for you to see them *as* parts of a Dalmatian.

Similar considerations apply in the auditory domain. One can know what someone is saying, and hear the sounds that they are making, without hearing them *as* saying those things. For example, you are traveling with a guide in a country where you don't know the language, and are about to stop at a small country inn. Your guide tells you that the first thing your host will say to you is that you are very welcome in his home. When your host opens the door he does, indeed, say that. Although you *know* he is saying that you are welcome, and although you hear him quite clearly, you don't hear him *as* saying that you are welcome in his home. This is because (since you don't know the language) the back-and-forth interpretive process that is a necessary condition for meaning-recognition fails to issue in a single integrated event-file into which both the sounds and their intended meaning are bound. On the contrary, although the two components are both present, they remain separate.

If concepts can be bound into the content of conscious perception, as I am proposing, then are there any limits on the abstractness of the concepts that can be so bound? I suggest that the only limits derive from the speed with which the applicability of the concept in question can be processed. In order to be globally broadcast as a component part of a perceptual object-file or event-file, conceptual information will need to be processed within the window of a few hundred milliseconds that elapses between presentation of a stimulus and its subsequent global broadcast. This could well be a function of expertise. While you or I might be capable of slowly figuring out, from the configuration of pieces on a chess board, that White has

a winning position, a chess grandmaster may immediately *see* it as such. And while you or I might be able to see that a bridge is sagging in the middle, a trained engineer may immediately *see* that it is about to collapse.

If this account is correct, then we should take seriously the phenomenological facts with which we began. When we see someone as intending to drink from a glass, or hear someone as speaking ironically (that is to say, saying the opposite of what they intend to communicate), the mental-state concepts in question are bound into the content of the perceptual state and globally broadcast as one of its components. Moreover, there seem to be no specific limits on the types of mental states that can be perceived. The only limit will be whether mindreading inferences can be drawn fast enough for binding to take place. Since many forms of mental-state awareness are seemingly simultaneous with awareness of the behavior and/or circumstances that cause them, we can presume that ordinary mindreaders *can* draw the requisite inferences quickly enough. Indeed, since the examples of the chess grandmaster and the engineer show that acquired skills and knowledge as well as innately channeled "modules" can result in appropriate forms of perceiving *as*, it should make no difference whether theorizing-theory accounts of mindreading development, or rather some form of innately modularized theory-theory view, turn out to be correct.

What is distinctive of theory-theory, as such, is a commitment to the view that mindreading depends on a body of generalizations (whether implicit or explicit) about mental states, their causes, and their interactions. Theorizing-theorists maintain that these generalizations are acquired in infancy and childhood through learning processes that are akin to scientific theorizing (Gopnik & Wellman, 1992). Others think that mindreading abilities are significantly innate, perhaps grounded in the processing principles at work in an innately-channeled domain-specific "module" of some sort (Carruthers, 2013; Scholl & Leslie, 1999). Either way, provided that the mindreading system can operate swiftly enough for its output to be bound into the content of the perceptual states that provide the basis for its interpretations, and globally broadcast along with the latter, then it will be possible for mental states to be perceived.[4]

Notice that it is consistent with this account that mental-state information, although produced as a result of perception, is sometimes processed too slowly to become incorporated into the perceptual state itself. This would then be a case where one perceives someone doing something, and knows why they are doing it, but without perceiving them *as* doing it for that reason or with that intention. Likewise, of course, the account is consistent with the familiar fact that one is sometimes only able to figure out why someone is doing something by engaging in various forms of conscious inference. The claim advanced here is only that *sometimes* (when mindreading proceeds swiftly enough for this to happen) mental-state concepts are bound into the content of perception and globally broadcast along with it.

Notice, however, that the present proposal also has the resources to allow for an additional possibility. Phenomenologically, it seems that one is sometimes initially unsure what someone intends to communicate by what she says. Perhaps one doesn't immediately hear her *as* joking, or *as* speaking ironically, for example, while not definitely hearing her as speaking literally, either. But while one sustains a representation of her utterance in working memory, the interpretation resolves itself (presumably as a result of unconscious mental-state reasoning) and one then *hears* the person *as* meaning the opposite of what she said (for example). The explanation is that the relevant mental-state information can become bound into the content of the sensory state that is sustained (and globally broadcast) in working memory subsequent to its *initial* (perceptual) global broadcast.

5. Against amodal working memory

I have argued that it is *plausible* that an awareness of the mental states of other people can be bound into the contents of visual or auditory perceptions and globally broadcast as components of those states. This account is consistent with the deeply interactive nature of perceptual processing. It also puts us in a position to explain how awareness of the mental states of other people can become access-conscious when we perceive their actions, appealing to attentional mechanisms about which much is already known. None of this is probative, however. But it is also possible to argue directly against the competing view that our awareness of the mental states of other people remains separate from the accompanying perceptions, and becomes access-conscious via a separate route. For this alternative account makes predictions that appear to be false, as I will now show.

If cognitive states can become access-conscious through a separate set of mechanisms from the ones underpinning access-conscious forms of perception, then one would expect that those mechanisms would play a role in the explanation of people's fluid general intelligence, or fluid *g*. This is because conscious forms of cognition play a large part, at least, in flexible forms of thinking and decision making of the sorts that are involved in tests of fluid *g*. But this expectation seems not to be fulfilled.

We know that the same attentional mechanisms that result in conscious forms of perception are also used off-line to sustain and manipulate conscious sensory-involving representations in working memory, using visual imagery, inner speech, and so on (Carruthers, 2015). Moreover, variations in people's abilities to control attention predict at least moderately large proportions of their variance in general intelligence (Shipstead, Redick, Hicks, & Engle, 2012; Unsworth & Spillers, 2010). And when combined with measures of speed of processing it is arguable that *all* of the variance in fluid *g* can thereby be explained (Carruthers, 2015). If there were a distinct set of mechanisms underlying conscious thinking and judging, in contrast, then one would expect them to make an independent contribution to variations in fluid *g*. Indeed, since *reflective* (conscious)

[4] One might wonder how the *output* of one system (in this case the mindreading system) could be bound into the representations that provide the *input* of that same system. But the claim is not that the output of the mindreading system is a component part of its own input. Rather, it is that back-and-forth processing taking place between the mindreading system and its perceptual input results in an integrated perceptual state containing mental-state concepts that is globally broadcast as a single unit.

thinking is one of the main predictors of success in reasoning tasks of many sorts (Stanovich, 1999, 2009), one would expect that the mechanisms underlying conscious thinking would account for a *large* part of the variance in people's general-purpose reasoning and problem-solving abilities (fluid *g*).

Note that working-memory tasks vary along a spectrum of abstractness, depending on whether the materials to be recalled and manipulated are purely sensory and nonconceptual (such as patterns or shapes for which one lacks any concepts), or whether those materials could be recalled and manipulated purely cognitively (for example, involving words or numbers). Tasks that are at the abstract end of this spectrum should benefit from both types of mechanism. For one can recall a list of words across an interval by sustaining the *concepts* that those words express, or by sustaining the *lexical items*, or by rehearsing the *sounds* of those words (or all three). Purely sensory, nonconceptual, tasks, in contrast, can rely only on the attentional and other mechanisms that result in and sustain conscious perceptions and sensory-like states. There are no concepts one can rehearse to help keep in mind a set of un-nameable shapes, for example. One would predict, then, that purely sensory working-memory tasks should correlate less strongly with measures of fluid general intelligence than do tasks that are of a mixed sensory–abstract sort.

The logic behind this prediction is worth elaborating a bit further. If there is just one set of sensory-based mechanisms that can result in the global broadcast of information in the brain, then reflective forms of thinking and reasoning, too, will be sensory-based. Conscious thinking will depend on sequences of visual or auditory imagery, imagined actions, inner speech, and so on. On this account, the only way for concepts and conceptual judgments to become access-conscious is by being bound into the content of globally broadcast sensory-involving states of some sort. And thus the correlation between measures of general intellectual abilities and sensory–attentional capacities should be high. In contrast, suppose that there are two sets of mechanisms that can result in access-conscious mental states—one that results in the global broadcast of sensory-based states and one that issues in the conscious status of judgments and other amodal, purely conceptual, states. In that case one would predict that each of these two mechanisms should make independent contributions to fluid general intelligence. And so measures of working memory ability that rely just on the sensory-based system should correlate less well with fluid *g* than do measures of working memory that can benefit from both systems.

To test this prediction, I searched for papers correlating working memory with fluid *g*, looking especially for those that utilize both concept-involving and nonconceptual tests of working memory, and which also provide details of correlations among individual tests. This search turned up five recent papers: Unsworth and Spillers (2010), Burgess, Gray, Conway, and Braver (2011), Redick, Unsworth, Kelly, and Engle (2012), Shipstead et al. (2012) and Shipstead, Lindsey, Marshall, and Engle (2014). All five employ two types of working-memory test that should unambiguously benefit from the involvement of concept-sustaining and manipulating mechanisms, if such things exist. All use *operation span* tests, which require one to recall lists of words, letters, or numbers while undertaking a secondary mathematical task. Four also use *reading span* tests, which have the same format except that the secondary task involves responding to sentences. The fifth instead uses two *running memory* tests (Shipstead et al., 2014), which require one to keep in mind serial lists of letters or numbers without any secondary task.

All five studies also use a type of test that appears to be nonconceptual (or at any rate a good deal *more* nonconceptual) in nature. These are *symmetry span* tests, which require one to keep a running memory of illuminated positions in a 4×4 grid interleaved with judgments of the symmetry of un-nameable geometric figures. Moreover, all five use a number of different tests of fluid general intelligence. Averaging across these five studies, the correlation between the concept-involving measures of working memory and the tests of fluid *g* is .35, whereas the correlation between the nonconceptual measure and the tests of fluid *g* is .40, somewhat *higher*, not lower.[5]

In addition, there is direct evidence that low-level sensory and attentional factors correlate with fluid intelligence about as closely as working memory itself does, thus providing further support for the claim that the latter is entirely sensory-based. Melnick, Harison, Park, Bennetto, and Tadin (2013) use a test that combined speed of sensory processing with automatic sensory suppression of large (as opposed to small) moving stimuli. (The suppression effect is thought to be an innate bias in the mechanisms that guide attention to ignore and suppress stimuli that are generally less likely to be relevant.) They find high correlations (of .65 and .71 in two experiments) between their low-level sensory measures and a variety of different measures of fluid general intelligence. Since we know that executively-controlled attention is also a vital component of working memory (as well as for tasks that measure fluid *g*), it appears from this study that there might be no variance in the latter remaining to be explained by the postulated cognition-specific broadcasting mechanisms.

Converging evidence is provided by a number of further studies, which have examined the relationship between capacities for sensory discrimination and fluid general intelligence in both children and adults (Acton & Schroeder, 2001; Deary, Bell, Bell, Campbell, & Fazal, 2004; Meyer, Hagmann-von Arx, Lemola, & Grob, 2010). The tests of sensory discrimination in question require people to order a series of color-chips by shade of color, to order a series of lines by length, to order a series of objects by manually-estimated weight, to order a series of tones by pitch, and so on. The tests are not time-limited, so speed of processing is unlikely to play much of a role. From these measures one can use factor-analysis to extract an underlying common factor that is shared by them all (much as one can extract *g* itself as a common factor underlying a number of measures of intelligence). Variance in sensory acuity across sensory modalities is thus washed out in this analysis. One can

[5] Note that these are correlations between tests of working memory and *tests* of fluid *g*, not fluid *g* itself (which is the underlying common factor extracted from a number of such tests). This might explain why the correlations reported here are lower than those generally found between working memory capacity and *g*, which normally range between .6 and .9 (Colom, Abad, Quiroga, Shih, & Flores-Mendoza, 2008; Colom, Rebollo, Palacios, Juan-Espinosa, & Kyllonen, 2004; Conway, Kane, & Engle, 2003; Cowan et al., 2005; Kane, Hambrick, & Conway, 2005; Redick et al., 2012; Unsworth & Spillers, 2010b; Shipstead et al., 2014).

then examine the correlations between this common factor and fluid *g*. These range between .68 and .92 across studies—that is, between *very strong* and *almost identical*.[6]

It is not yet clear what cognitive mechanisms constitute the common factor involved in sensory-discrimination tasks. But it is plausible that attentional control and sensory working memory are the main components. When one makes a judgment of the comparative pitch of two tones, for example, one has to hold in place a working-memory representation of the tone one has just heard, comparing it for pitch against the current stimulus, while resisting interference from memories of other recent tones. Even where one makes a simultaneous judgment of color or comparative length one needs to look back and forth between pairs for comparison, holding in working memory a representation of the one that has just been examined and comparing it with the object of current attention. What is surely quite clear, however, is that the underlying common factor in sensory-discrimination tasks cannot have anything to do with the properties of the supposed mechanisms that would result in the global broadcast of nonsensory thoughts and judgments.

In summary, then, the argument of this section is as follows:

(1) When we perceive other people's actions we often have access-conscious awareness of some of the mental states underlying those actions.
(2) If this awareness is not perceptual in character, then it must result from some other mechanism.
(3) Since this other mechanism would be responsible for the access-conscious status of conceptual judgments, it must play a significant role in explaining variations in fluid *g*.
(4) But the evidence suggests that variation in fluid *g* is fully explained by variance in abilities to control perceptual attention and sensory-based forms of working memory, combined with speed of processing.
(5) So our awareness of the mental states of other people is sometimes perceptual in character.

It may seem surprising that the question whether mental states are perceptible should turn on the nature of the mechanisms underlying fluid general intelligence. But recall that what is at stake in that question is the nature of the interface between perception and cognition. We know that not only are our perceptions of people's movements access-conscious, but so too (often), are the resulting judgments about their underlying mental states. If representations of mental states are bound into the contents of the perceptual ones and globally broadcast along with them, then it will be the same set of mechanisms that explains the access-conscious status of each. And the result will suggest an account of conscious forms of cognition that sees the latter as sensory-based (Carruthers, 2015). If conceptual judgments about other people's mental states become conscious through some other route, in contrast, then the mechanisms sustaining conscious cognition will be separate from those underlying conscious perception. And in that case we should expect there to be two sources of variance in people's general reasoning abilities: those that are implicated in the global broadcast of sensory images, and those that underlie the access-conscious status of our thoughts. Since the evidence supports the former of these views, we can conclude that our judgments about the mental states of other people are bound into the contents of attended perceptual states, thereby becoming conscious along with the latter.

6. Conclusion

I have argued that mental states of all sorts can be consciously perceived. While I have raised the question whether our perceptions of other people contain nonconceptual representations of their emotional and affective states as such, I have left this question unresolved. What I have argued, however, is that we can have *categorical* perceptions of the mental states of other people. We can see them as happy, or sad, or confused; and we can hear them as wondering what to have for dinner, or as judging that it is time to leave for the metro. The mental-state concepts in question are bound into the contents of our access-conscious perceptions and globally broadcast along with the latter.

I have offered two arguments for this account. One is that, given the evidence of interactive processing between conceptual and sensory systems during perception, we can *explain* how perceptual judgments can become access-conscious if (and only if) we suppose that concepts (including mental-state concepts) are bound into perceptual files and globally broadcast as components of the latter. The other argument is that if concepts and mental-state concepts can become access-conscious by some other route, then we would expect the systems involved to make a significant contribution to general intelligence; but this appears not to be so.

Moreover, these views have been defended from within a representationalist perspective on perceptual content generally, and in ways that are consistent with both nativist–modularist and theorizing-theory accounts of our mindreading competence.[7]

[6] Note, too, that this is essentially the same range of correlations as is generally found between working-memory capacities themselves and fluid *g*, which tend to fall between .6 and .9.

[7] Some portions of this paper are drawn, with appropriate alterations, from Carruthers (2015), with permission of Oxford University Press. I am grateful to two anonymous reviewers for their comments on an earlier version of this article.

References

Abell, F., Happé, F., & Frith, U. (2000). Do triangles play tricks? Attribution of mental states to animated shapes in normal and abnormal development. *Journal of Cognition and Development, 15*, 1–16.

Acton, G., & Schroeder, D. (2001). Sensory discrimination as related to general intelligence. *Intelligence, 29*, 263–271.

Bar, M., Kassam, K., Ghuman, A., Boshyan, J., Schmid, A., Dale, A., Hämäläinen, M., Marinkovic, K., Schacter, D., Rosen, B., & Halgren, E. (2006). Top-down facilitation of visual recognition. *Proceedings of the National Academy of Sciences, 103*, 449–454.

Barrett, H., Todd, P., Miller, G., & Blythe, P. (2005). Accurate judgments of intention from motion alone: A cross-cultural study. *Evolution and Human Behavior, 26*, 313–331.

Block, N. (1995). A confusion about the function of consciousness. *Behavioral and Brain Sciences, 18*, 227–247.

Block, N. (2005). Review of Alva Noë's *Action in Perception*. *The Journal of Philosophy, 102*, 259–272.

Burgess, G., Gray, J., Conway, A., & Braver, T. (2011). Neural mechanisms of interference control underlie the relationship between fluid intelligence and working memory span. *Journal of Experimental Psychology: General, 140*, 674–692.

Carruthers, P. (2013). Mindreading in infancy. *Mind & Language, 28*, 141–172.

Carruthers, P. (2015). *The Centered Mind: What the science of working memory shows us about the nature of human thought*. Oxford University Press.

Chaumon, M., Kveraga, K., Barrett, L., & Bar, M. (2013). Visual predictions in the orbitofrontal cortex rely on associative content. *Cerebral Cortex*. http://dx.doi.org/10.1093/cercor/bht146.

Clark, A. (2013). Whatever next? Predictive brains, situated agents, and the future of cognitive science. *Behavioral and Brain Sciences, 36*, 181–204.

Colom, R., Abad, F., Quiroga, A., Shih, P., & Flores-Mendoza, C. (2008). Working memory and intelligence are highly related constructs, but why? *Intelligence, 36*, 584–606.

Colom, R., Rebollo, I., Palacios, A., Juan-Espinosa, M., & Kyllonen, P. (2004). Working memory is (almost) perfectly predicted by *g*. *Intelligence, 32*, 277–296.

Conway, A., Kane, M., & Engle, R. (2003). Working memory capacity and its relation to general intelligence. *Trends in Cognitive Sciences, 7*, 547–552.

Cowan, N., Elliott, E., Saults, J. S., Morey, C., Mattox, S., Hismjatullina, A., & Conway, A. (2005). On the capacity of attention: Its estimation and its role in working memory and cognitive aptitudes. *Cognitive Psychology, 51*, 42–100.

Deary, I., Bell, P., Bell, A., Campbell, M., & Fazal, N. (2004). Sensory discrimination and intelligence: Testing Spearman's other hypothesis. *American Journal of Psychology, 117*, 1–18.

Dennett, D., & Kinsbourne, M. (1992). Time and the observer. *Behavioral and Brain Sciences, 15*, 183–201.

Dretske, F. (1979). Simple seeing. In D. Gustafson & B. Tapscott (Eds.), *Body, mind, and method*. Reidel.

Gallagher, S. (2001). The practice of mind: Theory, simulation, or primary interaction? *Journal of Consciousness Studies, 8*, 83–107.

Gao, T., McCarthy, G., & Scholl, B. (2010). The wolfpack effect: Perception of animacy irresistibly influences interactive behavior. *Psychological Science, 21*, 1845–1853.

Goldstone, R. (1994). Influences of categorization on perceptual discrimination. *Journal of Experimental Psychology: General, 123*, 178–200.

Goldstone, R., Lippa, Y., & Shiffrin, R. (2001). Altering object representations through category learning. *Cognition, 78*, 27–43.

Gopnik, A., & Wellman, H. (1992). Why the child's theory of mind really *is* a theory. *Mind & Language, 7*, 145–171.

Hatfield, E., Cacioppo, J., & Rapson, R. (1994). *Emotional contagion*. Cambridge University Press.

Heider, F., & Simmel, M. (1944). An experimental study of apparent behavior. *American Journal of Psychology, 57*, 243–259.

Husserl, E. (1973). *Experience and judgment: Investigations in the genealogy of logic*. In L. Landgrebe (Ed.), Translated by J. Churchill & K. Ameriks. Routledge.

Hutto, D. (2004). The limits of spectatorial folk psychology. *Mind & Language, 19*, 548–573.

Kahneman, D., Triesman, A., & Gibbs, B. (1992). The reviewing of object files: Object specific integration of information. *Cognitive Psychology, 24*, 175–219.

Kahneman, D., & Triesman, A. (1984). Changing views of attention and automaticity. In R. Parasuraman & D. Davies (Eds.), *Varieties of attention*. Academic Press.

Kane, M., Hambrick, D., & Conway, A. (2005). Working memory capacity and fluid intelligence are strongly related constructs. *Psychological Bulletin, 131*, 66–71.

Klin, A. (2000). Attributing social meaning to ambiguous visual stimuli in higher functioning autism and Asperger syndrome: The social attribution task. *Journal of Child Psychology and Psychiatry, and Allied Disciplines, 41*, 831–846.

Kosslyn, S. (1994). *Image and brain*. MIT Press.

Lupyan, G. (2012). Linguistically modulated perception and cognition: The label-feedback hypothesis. *Frontiers in Psychology, 3*, 54.

McDowell, J. (1994). *Mind and world*. MIT Press.

Melnick, M., Harison, B., Park, S., Bennetto, L., & Tadin, D. (2013). A strong interactive link between sensory discriminations and intelligence. *Current Biology, 23*, 1013–1017.

Meyer, C., Hagmann-von Arx, P., Lemola, S., & Grob, A. (2010). Correspondence between the general ability to discriminate sensory stimuli and general intelligence. *Journal of Individual Differences, 31*, 46–56.

Mo, L., Xu, G., Kay, P., & Tan, L.-H. (2011). Electrophysiological evidence for the left-lateralized effect of language on preattentive categorical perception of color. *Proceedings of the National Academy of Sciences, 108*, 14026–14030.

Noë, A. (2004). *Action in perception*. MIT Press.

Panichello, M., Cheung, O., & Bar, M. (2013). Predictive feedback and conscious visual experience. *Frontiers in Psychology, 3*, 620.

Pylyshyn, Z. (2003). *Seeing and visualizing*. MIT Press.

Rauss, K., Schwartz, S., & Pourtois, G. (2011). Top-down effects on early visual processing in humans: A predictive coding framework. *Neuroscience and Biobehavioral Science Reviews, 35*, 1237–1253.

Redick, T., Unsworth, N., Kelly, A., & Engle, R. (2012). Faster, smarter? Working memory capacity and perceptual speed in relation to fluid intelligence. *Journal of Cognitive Psychology, 24*, 844–854.

Rutherford, M., Pennington, B., & Rogers, S. (2006). The perception of animacy in young children with autism. *Journal of Autism and Developmental Disorders, 36*, 983–992.

Scholl, B., & Gao, T. (2013). Perceiving animacy and intentionality: Visual processing or higher-level judgment? In M. Rutherford & V. Kuhlmeier (Eds.), *Social Perception: Detection and interpretation of animacy, agency, and intention*. MIT Press.

Scholl, B., & Leslie, A. (1999). Modularity, development, and "Theory of Mind". *Mind & Language, 14*, 131–153.

Shipstead, Z., Lindsey, D., Marshall, R., & Engle, R. (2014). The mechanisms of working memory capacity: Primary memory, secondary memory, and attention control. *Journal of Memory and Language, 72*, 116–141.

Shipstead, Z., Redick, T., Hicks, K., & Engle, R. (2012). The scope and control of attention as separate aspects of working memory. *Memory, 20*, 608–628.

Smith, J. (2010). Seeing other people. *Philosophy and Phenomenological Research, 81*, 731–748.

Stanovich, K. (1999). *Who is rational? Studies of individual differences in reasoning*. Lawrence Erlbaum.

Stanovich, K. (2009). *What intelligence tests miss: The psychology of rational thought*. Yale University Press.

Thierry, G., Athanasopoulos, P., Wiggett, A., Dering, B., & Kuipers, J.-R. (2009). Unconscious effects of language-specific terminology on preattentive color perception. *Proceedings of the National Academy of Sciences, 106*, 4567–4570.

Unsworth, N., & Spillers, G. (2010). Working memory capacity: Attention control, secondary memory, or both? A direct test of the dual-component model. *Journal of Memory and Language, 62*, 392–406.

Veillet, B., & Carruthers, P. (2011). The case against cognitive phenomenology. In T. Bayne & M. Montague (Eds.), *Cognitive phenomenology*. Oxford University Press.

Vetter, P., & Newen, A. (2014). Varieties of cognitive penetration in visual perception. *Consciousness and Cognition, 27*, 62–75.

Witzel, C., & Gegenfurtner, K. (2011). Is there a lateralized category effect for color? *Journal of Vision, 11*(12), 16.

Wyatt, D., Jilk, D., & O'Reilly, R. (2014). Early recurrent feedback facilitates visual object recognition under challenging conditions. *Frontiers in Psychology, 5*, 674.