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# Simulation is not enough: A hybrid model of disgust attribution on the basis of visual stimuli

Luca Barlassina

*Mindreading is the ability to attribute mental states to other individuals. According to the Theory-Theory (TT), mindreading is based on one's possession of a Theory of Mind. On the other hand, the Simulation Theory (ST) maintains that one arrives at the attribution of a mental state by simulating it in one's own mind. In this paper, I propose a ST-TT hybrid model of the ability to attribute disgust on the basis of visual stimuli such as facial expressions, body postures, etc. More precisely, while I defend Goldman's (2006) thesis that the ability to attribute disgust based on observing disgusted facial expressions stems from a mirror-based simulation process, I argue that ST is unable to account for the ability to attribute disgust based on non-facial visual stimuli; I propose, rather, that this latter ability is theory-based. My model is grounded in evidence from individuals suffering from Huntington's Disease.*

*Keywords: Disgust; Huntington's Disease; Mindreading; Mirror Neurons; Simulation Theory; Theory-Theory*

## 1. Introduction

Mindreading is the ability to attribute mental states to other individuals. To wit, if I believe that Mary desires to visit London, or that she is disgusted, or that she intends to grasp a mug, I am performing an act of mindreading. The two most influential accounts of the cognitive mechanisms underlying mindreading are the Theory-Theory (TT) and the Simulation Theory (ST). According to TT, mindreading is based on the knowledge of a Theory of Mind (Gopnik & Meltzoff, 1997; Gopnik & Wellman, 1992; Scholl & Leslie, 1999; Stich & Nichols, 1992). On the contrary, ST maintains that one does not need to have such knowledge, since one is able to attribute a mental state by simulating it in one's own mind (Currie & Ravenscroft,

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2002; Gallese & Goldman, 1998; Goldman, 1989, 2006; Gordon, 1986; Heal, 2003). In this paper, I propose a cognitive model of the ability to attribute disgust on the basis of visual stimuli, such as facial expressions, body postures, and so forth. I claim that this ability involves both simulation of disgust and theoretical knowledge of it. In other words, I propose a ST-TT hybrid model.

In discussing the attribution of disgust, my focus will be narrow in at least two ways. First, my interest is limited to how we attribute *core disgust* (Ekman, 1992; Rozin, Haidt, & McCauley, 2008)—that is, the basic emotional state which:

- (1) (*Functional description*) is caused by perceiving rotten food, excrement, unpleasant odors, etc., and causes rejection behaviors, nausea, a characteristic facial expression, etc.;<sup>1</sup> and
- (2) (*Phenomenological description*) is characterized by a qualitative feel of revulsion—the subjective experience of disgust.<sup>2</sup>

Accordingly, I shall not consider the attribution of other types of disgust, such as moral disgust.<sup>3</sup> Second, I'll limit my attention to the ability to attribute disgust on the basis of visual stimuli. Thus, I won't say a word about how we attribute disgust on the basis of non-visual stimuli—for example, auditory stimuli, whether verbal or non-verbal.

My ST-TT hybrid model is based largely on evidence from Huntington's Disease (HD), and is intended as a supplement to the simulationist model of face-based disgust attribution that has been proposed by Goldman (2006, 2008, 2009; Goldman & Sripada, 2005).<sup>4</sup> The next section introduces the version of ST developed in Goldman (2006). In the third section, I focus on Goldman's simulationist model of the ability to attribute disgust based on observation of disgusted facial expressions, and I argue that this model is supported by experimental studies of people suffering from HD. The fourth section, on the other hand, describes very recent findings on HD that indicate that Goldman's model cannot be extended to the ability to attribute disgust on the basis of non-facial visual stimuli. In the fifth section, I argue that no plausible version of ST can account for this ability. In the sixth section, I propose a TT model for the ability to attribute disgust on the basis of non-facial visual stimuli. Finally, the seventh section discusses some differences between simulation-based and theory-based disgust attributions from visual stimuli.

## 2. Goldman's Simulation Theory

What are the cognitive mechanisms underlying mindreading? In answering this question, ST starts from the commonsensical idea that we understand what other people think, feel, etc., by "putting ourselves in their shoes." In terms of ST, this means that one arrives at attributing a mental state by simulating it in one's own mind (Currie & Ravenscroft, 2002; Gallese & Goldman, 1998; Goldman, 1989, 2006; Gordon, 1986; Heal, 2003). ST comes in many varieties, and there is no unique notion of simulation that is shared by all supporters. For my purposes, the following rough characterization of what 'simulation' means in this context will do: a subject S

simulates a token mental state  $T$  if and only if  $S$  produces in her own mind a token mental state  $T'$  that is significantly similar to  $T$ .<sup>5</sup> So, if we label the individual who attributes a mental state the 'mindreader', and label the individual to whom the mental state is attributed the 'target', we can characterize  $ST$  as follows: the mindreader's ability to understand the target's mind is based on her ability to simulate the target's mental states and processes. In this section of the paper, I am illustrating the version of  $ST$  that was developed by Goldman in his (2006) and subsequent works.

According to Goldman, mindreading is a three-step process. First, the mindreader simulates the target's mental states and processes within her own mind; this is, strictly speaking, the simulation process. Second, the mindreader introspects the outcome of the simulation process, and categorizes it. Third, the mindreader attributes the categorized state to the target. In order to understand this abstract model, let's consider the following standard example. Imagine that I am the mindreader, and Mary is the target. I believe that Mary desires to drink a beer, and I believe that she believes that if she goes in the kitchen she will find one. Suppose now that I want to predict what Mary will decide to do. According to Goldman, this is how I attribute a decision to Mary. First, I simulate Mary's decision-making process—that is, I imagine believing and desiring what Mary believes and desires, and I put these imaginative states in my own decision-making mechanism, which then produces the pretend decision to go in the kitchen, i.e., a decision that does not cause any action. At this point, I introspect the outcome of that simulation process, and I categorize it as a decision to go in the kitchen. Finally, I project that decision onto Mary—that is, I attribute to Mary the decision to go in the kitchen.

When mindreading stems from an imagination-based process of simulation, as in the example I have just considered, it is called *high-level* simulational mindreading (Goldman, 2006). However, Goldman also acknowledges the existence of another type of simulational mindreading, in which the simulation process is not underpinned by imagination, but rather by mirroring processes (Goldman, 2006, 2008). In order to explain this idea, I have to first say a few things about mirror neurons (MNs). MNs are a specific class of neurons that were originally discovered in the ventral premotor cortex (area F5) of macaque monkeys (di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Gallese, Fadiga, Fogassi, & Rizzolatti, 1996; Rizzolatti, Fadiga, Gallese, & Fogassi, 1996). MNs were initially defined as sensorimotor neurons that fire both when an agent performs some kind of goal-directed action (e.g., grasping an object, bringing it to the mouth) and when she observes the same type of action performed by another individual (Gallese et al., 1996; Gallese & Goldman, 1998; Rizzolatti, Fogassi, & Gallese, 2001). For example, when an agent grasps a mug, her MNs code the motor act GRASPING. This counts as an *endogenous* activation of MNs. Suppose, now, that another individual is observing that agent grasping the mug. The observer's MNs code the motor act GRASPING as well, even though the observer is not herself performing the act. This counts as an activation of MNs in *observation mode*. Since the MNs in the observer reproduce the activity of the MNs in the agent, activations of MNs in observation mode are

instances of mental simulation. Goldman (2008) defines mirroring processes as activations of MNs in observation mode. It follows that mirroring processes are instances of mental simulation. Thus, simulation processes can be either imagination-based or mirror-based. When an act of mindreading stems from a mirror-based simulation process, Goldman (2006) describes it as a case of *low-level* simulational mindreading.

Even though MNs were originally discovered in the domain of actions, in recent years a number of studies have established the existence of mirroring processes for emotions and sensations as well (Avenanti, Bueti, Galati, & Aglioti, 2005; Gallese, Keysers, & Rizzolatti, 2004; Keysers et al., 2004; Singer et al., 2004; Wicker et al., 2003). This discovery has forced a revision of the initial definition of MNs given above. To my knowledge, the best non-restricted definition of MNs has been proposed by Goldman himself: “MNs are a class of neurons that discharge both when an individual undergoes a certain mental event *endogenously* and when it observes a *sign* that another individual undergoes the same type of mental event” (Goldman, 2008, p. 313). In the next section, I will focus on the discovery made by Wicker and colleagues (Wicker et al., 2003) of a mirroring process for disgust. I will also examine Goldman’s idea that this mirroring process is what grounds the ability to attribute disgust based on observation of disgusted facial expressions. In other words, I will consider Goldman’s idea that face-based disgust attribution is a case of low-level simulational mindreading.

### 3. Face-Based Disgust Attributions and Simulation

The claim that face-based disgust attribution is a case of low-level simulational mindreading has been made by Goldman in a series of works (Goldman, 2006, 2008, 2009; Goldman & Sripada, 2005).<sup>6</sup> He subscribes to the following two theses:

- (1) Observing someone else’s disgusted facial expression triggers a mirrored experience of disgust in the observer.
- (2) This mirrored experience of disgust plays a causal role in face-based disgust attribution.

Since I maintain that Goldman’s simulationist model of face-based disgust attribution is correct, in this section I will outline the points in favor of (1) and (2). First, I briefly illustrate Goldman’s argument for (1), for which he largely builds on Wicker et al. (2003). Then, I give an argument for (2) that crucially relies on evidence from Huntington’s Disease—a type of evidence that Goldman has only marginally considered.<sup>7</sup>

Let’s begin with (1). The experience of disgust is normally evoked by the perception of disgusting stimuli, for example, rotten food, excrement, or unpleasant odors. It has been shown that the anterior insula is selectively activated in response to disgusting stimuli (Small et al., 2003). This suggests that the anterior insula is linked to the experience of disgust. This putative link has been confirmed by a study in which subjects who underwent stimulation of this brain area reported disgust-related

sensations and feelings (Krolak-Salmon et al., 2003). It is interesting to note that brain imaging studies have established that the anterior insula is also activated by the observation of disgusted facial expressions (Phillips et al., 1997, 1998). One may hypothesize, then, that perceiving disgusted facial expressions also evokes the experience of disgust. In order to test this hypothesis, Wicker et al. (2003) carried out an fMRI study in which the same participants observed video clips that showed disgusted facial expressions, and subsequently inhaled odorants that produced a strong feeling of disgust. It turned out that the same neural substrate—namely, the left anterior insula—that was preferentially activated during the experience of disgust was also preferentially activated during the observation of the disgusted facial expressions. According to Goldman, this constitutes evidence that observing someone else's disgusted facial expression elicits a mirrored experience of disgust in the observer—that is, it constitutes evidence for (1).

The mirrored experience of disgust differs from the (standard) experience of disgust in two ways. First, while the experience of disgust is caused by perceiving disgusting stimuli, the mirrored experience of disgust is caused by observing a sign that someone else is undergoing an experience of disgust. Consequently, a mirrored experience of disgust is a simulation of the experience of disgust. Second, the experience of disgust is usually phenomenologically more vivid than its simulated counterpart. As we know, however, these two experiences of disgust share a common neural underpinning, i.e., the left anterior insula. Thus, if an individual loses the capacity to experience disgust as a result of damage to the insula, she presumably also loses the capacity to have the mirrored experience of disgust—and vice versa. This is the reason why, as we'll see in a moment, Goldman's strategy to establish (2) consists of pointing to neuropsychological patients with a deficit in the experience of disgust, and then assessing their ability to attribute disgust on the basis of observing disgusted facial expressions.

We are now in a position to discuss (2). As Goldman points out, Wicker et al.'s study is not sufficient to allow us to draw a conclusion about the cognitive mechanisms that underlie face-based disgust attribution, because their study did not include any tasks that explicitly tested the ability to attribute emotion. Moreover, even if Wicker et al.'s experimental participants had been asked to attribute a mental state to the individuals in the video clips, this would at best have established a correlation between a mirrored experience of disgust and face-based disgust attribution, and not a causal link between them. In order to find evidence for the thesis that mirrored experiences of disgust play a causal role in face-based disgust attribution, Goldman turned to the neuropsychological cases of patient NK, studied by Calder, Keane, Manes, Antoun, and Young (2000), and patient B, studied by Adolphs, Tranel, and Damasio (2003). Calder et al. and Adolphs et al. described their patients as selectively impaired in experiencing disgust following extensive damage to the insula. If a mirrored experience of disgust were indeed causally implicated in face-based disgust attribution, then, these two patients should also be impaired in that mindreading ability. Along the lines of this prediction, Calder et al. and Adolphs et al. found that NK and B were selectively impaired in the ability to attribute disgust on



the basis of observation of disgusted facial expressions. Based on these results, Goldman concluded that attribution of disgust from the observation of disgusted facial expressions is causally based on a mirrored experience of disgust—i.e., (2).

Even though it is my view that (2) is correct, the evidence from the cases of NK and B is not particularly persuasive. In fact, there is only weak evidence for the thesis that these two patients really had a deficit in the experience of disgust. Adolphs et al. did not perform any experimental tests to assess B's experience of disgust; rather, their conclusion that B was impaired was based only on everyday interactions with the patient. Calder et al. did administer a test to patient NK, but they employed Haidt's Disgust Scale (Haidt, McCauley, & Rozin, 1994), a method whose reliability has been questioned (e.g., Hayes, Stevenson, & Colheart, 2007; Sprengelmeyer et al., 1996). The main problem with Haidt's Disgust Scale is that although it was conceived as a test for individual disgust sensitivity, it is a verbal questionnaire, and thus it hardly taps into emotion experience. Rather, it reveals one's knowledge about disgust. As a result, the evidence that Goldman reported appears to be insufficient to establish his point that mirrored experience of disgust is causally involved in face-based disgust attribution. However, there is additional evidence that mirrored experience of disgust does play just such a causal role. This evidence comes from studies of people living with Huntington's Disease (HD).

HD is an inherited neurodegenerative disorder caused by the Huntington's Disease gene (HD gene), a mutated version of the Huntington's gene (Goldberg, Telenius, & Hayden, 1994). HD is characterized by involuntary choreiform motions as well as cognitive and affective impairments (Craufurd & Snowden, 2002). Notably, individuals with HD show impairment in the experience of disgust. They may exhibit poor personal hygiene, and it has been demonstrated that they have significantly abnormal responses to disgust-provoking events. For instance, Mitchell, Heims, Neville, and Rickards (2005) discovered that individuals with HD failed to respond normally when presented with disgusting smells (e.g., vomit-like odors) or disgusting tastes (e.g., ketchup with yogurt). To be sure, since deficiencies in olfactory and gustatory perception have been reported with HD (Bylsma, Moberg, Doty, & Brandt, 1997), one might argue that the abnormal response to disgusting odors and tastes was due to a general perceptual defect in these sensory domains. However, the individuals with HD who participated in Mitchell et al.'s study did not differ from the comparison group in either general olfactory ability, or rating of pleasant gustatory or olfactory stimuli. Accordingly, Mitchell et al.'s data are best explained by the hypothesis that individuals with HD are selectively impaired in experiencing disgust.<sup>8</sup>

If a mirrored experience of disgust is causally involved in face-based disgust attribution, then we should see a deficit in this ability in individuals with HD. This is indeed the case. Several studies have shown that individuals with HD are strongly impaired in attributing disgust on the basis of observation of disgusted facial expressions (Hayes et al., 2007; Sprengelmeyer et al., 1996; Wang, Hoosain, Yang, Meng, & Wang, 2003), even at the pre-symptomatic stage of HD (Gray, Young, Barker, Curtis, & Gibson, 1997; Sprengelmeyer, Schroeder, Young, & Epplen, 2006).

Hence, individuals with HD have a double deficit in disgust experience and disgust attribution.

Recall that the anterior insula has an important role in the experience of disgust (Krolak-Salmon et al., 2003; Small et al., 2003), and that the left anterior insula is the neural substrate of disgust mirroring (Wicker et al., 2003). Notably, Hennenlotter et al. (2004) performed an fMRI study aimed at investigating the neural correlate of pre-symptomatic HD gene carriers' impairment in face-based disgust attribution, and established that such impairment is correlated with reduced responses in the left anterior insula. In line with this result, Kipps, Duggins, McCusker, and Calder (2007) discovered that pre-symptomatic HD gene carriers' impairment in face-based disgust attribution is correlated with the volume of the anterior insula: the greater the insular atrophy, the most severe the disgust recognition deficit. These findings strongly suggest that the HD difficulties with face-based disgust attribution are due to an impairment in mirroring others' disgust experiences.

In summation, when all the data that I have considered in this section are put together, they constitute considerable evidence for (1) and (2)—that is, for the idea that “when normal individuals recognize disgust when viewing the facial expression of disgust, this recognition is causally based on the production in the viewer of a mirrored experience of disgust” (Goldman, 2008, p. 318). In other words, we have evidence for Goldman's claim that face-based disgust attribution is a case of low-level simulational mindreading. In the next section, I will consider whether Goldman's simulation model for face-based disgust attribution can be extended to the ability to attribute disgust on the basis of *non*-facial visual stimuli.

#### 4. Non-Facial Visual Information and Huntington's Disease

The ability to attribute emotions on the basis of observation of facial expressions is usually assessed by presenting the mindreader with a picture of an isolated facial expression, without any other contextual cues that might facilitate the recognition of the emotion expressed by the face (Ekman & Friesen, 1975). In assessments of this kind, then, the mindreader does not have access to other relevant information that is usually available in ordinary situations. Consider, for instance, the following story: Mary and I are hiking together in the woods when a snake suddenly jumps out. At the sight of the snake, Mary screams, her facial expression changes, and she rapidly runs away from the snake. She is terrified. On what basis did I attribute this fear to Mary? Of course, her scream was an important clue; but since we're only concerned with visual information, let's put the scream aside. There was her facial expression. Additionally, there were two pieces of *non-facial visual information*: first, the fact that I saw Mary running away from where she had been, and second, the fact that I saw a snake nearby. The moral of the story is this: in everyday contexts, a mindreader can attribute a mental state to a target by considering, in addition to the target's facial expression, visual information concerning (a) the emotional body language of the



target, and (b) the objects in the vicinity of the target. I call the non-facial visual information given in (a) and (b) ‘Contextual Visual Information’ (CVI).

A couple of comments about CVI are in order. First, the expression ‘body language’ is a sort of catchall term. Under this label we may find elements as distinct as static body postures, dynamic behaviors and movements, or even organized, meaningful actions (de Gelder, 2006). Since I am about to discuss an experiment wherein subjects were only presented with still pictures, I will use the expression ‘body language’ to refer simply to *body postures*. My second comment concerns (b). It is true that ‘objects in the vicinity of the target’ is a loose notion. Its lack of precision, however, is not a bad feature, given that in ordinary situations many different contextual cues can help a mindreader to attribute a mental state to a target. The only requirement I introduce is that the mindreader should believe that the target, too, is perceiving, or has perceived, these objects. For example, it would have made no sense for me to attribute fear to Mary based on noticing a snake in her surroundings if I had not believed that Mary had seen the snake as well.

Let’s ask now: if individuals with HD were presented with CVI, would they be able to attribute disgust? According to Goldman’s simulationist model of disgust attribution, a mirrored experience of disgust plays a crucial causal role in the ability to attribute disgust. Individuals with HD cannot experience disgust. Hence, if the ability to attribute disgust on the basis of CVI were to be a case of low-level simulational mindreading, individuals with HD should be impaired in this ability. But are they so impaired? This question can be answered by considering an experiment conducted by Aviezer et al. (2009). Aviezer et al.’s participants were 21 individuals in the early stages of HD, whom they assessed for the ability to attribute disgust on the basis of facial expressions and CVI. To begin with the first ability, participants were presented with isolated facial expressions typical of anger, disgust, happiness, and sadness. Experimenters asked participants to choose which emotion name from a list of six basic emotions (happiness, sadness, surprise, disgust, anger, fear) best described the observed facial expression. Despite normal visual ability and the ability to recognize identity from faces, individuals with HD were, as expected, severely impaired in face-based disgust attribution. Regarding the ability to attribute disgust on the basis of CVI, Aviezer et al. presented participants with an image of a man in a revolted body posture (emotional body language of target), and handling a pair of dirty underwear (object in vicinity of the target). Crucially, the face of the man was cut off of the image (Figure 1). As in the previous task, participants chose which of a list of six basic emotions best described the emotion that the target was undergoing. The striking discovery was that individuals with HD displayed an intact capacity to attribute disgust on the basis of CVI; Aviezer et al. reported that individuals with HD were “similar to controls in perceiving...disgust from emotion-portraying bodies and scenes” (Aviezer et al. 2009, p. 1638).

Recall that individuals with HD are impaired in experiencing disgust. Thus, their ability to attribute disgust from observing (a) and (b) cannot be based on a mirrored experience of disgust. It follows that Goldman’s simulationist model of face-based disgust attribution cannot be extended to the capacity to attribute disgust on the



**Figure 1** Picture Used to Assess Disgust Attribution Based on Non-facial Visual Stimuli.  
 Source: Aviezer et al. (2009), p. 1636.

basis of CVI. More precisely, by putting together the data on face-based disgust attribution with the results from Aviezer et al., it is possible to conclude that there exist at least two dissociable mechanisms for disgust attribution on the basis of visual stimuli. One is the mirror-based simulation mechanism described by Goldman, which processes (at least) facial stimuli. This mechanism is impaired in individuals with HD. The second mechanism processes (at least) CVI, and is intact in the HD population. I will attempt to describe the nature of this latter mechanism in the next two sections.

### 5. Simulation is not Enough

The first important task is to establish what the mechanism for attributing disgust on the basis of CVI cannot be. The fact that individuals with HD are impaired in experiencing disgust excludes the notion that attribution of disgust on the basis of CVI might be a case of low-level simulational mindreading. As we know, however, Goldman acknowledges another type of simulational mindreading—high-level simulational mindreading—in which the simulation process is not based on mirroring processes, but rather on imagination. Can the ability to attribute disgust from CVI be a case of high-level simulational mindreading? That is, can it be based on imagination? To answer this question, we must first observe that when Goldman talks about imagination-based simulation, he has in mind a particular type of imagination, namely enactment imagination (E-imagination). This is how Goldman describes E-imagination:

In ordinary language, the verb *imagine* sometimes takes a *that*-clause complement, and in this construction, imagining that *p* is roughly equivalent to *supposing* that *p*. . . . [However] there is a different syntactic construction: “imagine *M*-ing” or “imagine feeling *M*.” For example, I can . . . imagine *feeling* elated. . . . When I imagine feeling elated, I do not merely suppose *that* I am elated; rather, I *enact*, or

try to enact, elation itself. Thus, we might call this type of imagination *enactment imagination*. (Goldman, 2006, p. 47)

To make a long story short, E-imagining a mental state M is a process that generates a mental state M' that resembles M in some important respects (for more details, see Goldman 2006, chapter 7). For instance, when one imagines feeling elated, one tries to create elation in oneself, and one usually ends up with a surrogate of elation—that is, with a “state that feels, phenomenologically...like a trace or tincture of elation” (Goldman, 2006, p. 47). Mutatis mutandis, when one E-imagines feeling disgusted, one tries to enact the experience of disgust, ending up with a state that phenomenologically resembles a genuine experience of disgust.<sup>9</sup> Individuals with HD cannot experience disgust. Hence, given the characterization of E-imagination given by Goldman, it would be very surprising if individuals with HD were able to E-imagine disgust. But if individuals with HD are prevented from E-imagining disgust, then the ability to attribute disgust on the basis of CVI is not a case of high-level simulational mindreading. Thus, the ability to attribute disgust on the basis of CVI is neither a case of low-level nor of high-level simulational mindreading. Since the version of ST developed by Goldman only features these two types of simulational mindreading, it follows that Goldman's ST lacks the resources to account for the ability to attribute disgust on the basis of CVI.

Does the fact that Goldman's ST cannot explain attribution of disgust from CVI imply that this mindreading ability does not stem from simulation? It does not, since there are other ways to conceive of ST. In particular, one may propose a *purely behavioral* account of simulation according to which one does not need to simulate the emotional experience of the target in order to attribute disgust on the basis of CVI, but only to mimic, presumably in a covert way, the emotional body language of the target. There are three reasons to be a skeptic about this alternative simulationist model, too.

A first objection to a purely behavioral simulationist account of the ability to attribute disgust from CVI is the following. HD strongly damages basal ganglia, a set of neural structures involved in motor cognition (Dum & Strick, 2009). As a consequence, individuals with HD exhibit severe motor deficits. Thus, individuals with HD should encounter difficulties in mimicking the body language of other people. Furthermore, there is evidence that individuals with HD are impaired in recognizing emotional body language, and that this impairment is correlated with their motor deficits (de Gelder, Van den Stock, de Diego Balaguer, & Bachoud-Lévi, 2008). This strongly suggests that the ability of individuals with HD to attribute disgust on the basis of CVI does not stem from the ability to mimic the emotional body language of other people. This objection, however, is not conclusive. Indeed, Aviezer et al. (2009) studied people in the early stages of HD who showed only mild motor symptoms. Hence, it is not impossible that their attributions of disgust from CVI were based on a process of body mimicry. To rule out this possibility, one should consider the ability to attribute disgust on the basis of CVI in individuals who

are in the advanced stages of HD. Unfortunately, as far as I know, no such study has yet been performed, so more evidence is still needed to settle the question.

A second objection to a purely behavioral simulationist model hinges on the question of how the mindreader would proceed from mimicking the target's body posture to attributing disgust to the target. It is a platitude that there is a causal relationship between the experience of a given basic emotion and the production of a characteristic facial expression. As Goldman and Sripada (2005) have noted, this causal relationship seems to be bi-directional: making the appropriate facial expression tends to generate, presumably in an attenuated form, the experience of the corresponding basic emotion. If one supposes that there is a characteristic body posture for disgust, a posture such that the experience of disgust both causes it and is caused by it, then one could propose the following story about the role of motor mimicry in disgust attribution from CVI. The mindreader observes a disgust-characteristic body posture. This activates covert body mimicry in her. The production of that disgust-characteristic body posture by the mindreader in turn generates an (attenuated) experience of disgust in her. The mindreader then classifies her own experience as a state of disgust, and, finally, attributes disgust to the person she is observing. So far, so good. However, this way of spelling out the purely behavioral simulationist model transforms it into a *non*-purely behavioral simulationist model. Rather, the passage from body mimicry to the attribution of disgust is now mediated by the experience of disgust. Hence, this model faces the same difficulties as Goldman's model. To solve them, one would need to come up with a model in which the mindreader passes from mimicking a disgust-characteristic body posture to attributing disgust *without* the intermediary of the experience of disgust. However, it is not clear how this hypothetical model could work.

For the sake of argument, however, let's grant that it is possible to build a general, purely behavioral simulationist model of emotion attribution in which experience plays no role at all. Even granting this, I maintain—and this is my third and last objection—that this model cannot be successfully applied to the case of disgust attribution from CVI. The reason is that there is no such thing as a characteristic body posture for disgust. Let's consider the experiment by Aviezer et al. again. They described the man depicted in figure 1 as being in a revolted body posture. However, we can infer that it is a revolted body posture only because we see that the man is handling a pair of dirty underwear. If he were handling another type of object, such as a pencil, we would describe him as, say, exerting a precision grip, while showing an emotionally neutral body posture. In other words, while there seems to be a one-to-one correspondence between the experience of disgust and a characteristic facial expression, there is no body posture that is univocally correlated with disgust. If there is no disgust-characteristic body posture, then trying to explain disgust from CVI by means of body mimicry is a hopeless project. Hence, attribution of disgust from CVI cannot be accounted for either by Goldman's simulationist model or by a purely behavioral simulationist model. My conclusion is that ST is not able to make sense of this mindreading ability.

## 6. A Theory-Theory Alternative

CVI is composed of two elements: (a) the emotional body language of the target, and (b) the objects in the vicinity of the target. In the previous section, I showed that ST lacks the resources to explain the ability to attribute disgust from CVI. Moreover, I showed that this ability cannot be based on (a), since there is no body posture univocally correlated with disgust. Thus, we are looking for a non-simulationist model that makes crucial reference to (b). In this section, I propose a TT model in which (b) plays an essential role. Before introducing the model, let me outline the TT approach to mindreading.

According to TT, mindreaders tacitly know a Theory of Mind—i.e., a set of folk-psychological laws that connect sensory stimuli, mental states, and behavioral responses—and deploy this knowledge in order to infer others' mental states (Gopnik & Meltzoff, 1997; Gopnik & Wellman, 1992; Scholl & Leslie, 1999; Stich & Nichols, 1992). Consider the following case. I have two beliefs about Mary's current mental states. I believe that:

- (1) Mary desires to drink a beer.
- (2) Mary believes that if she goes in the kitchen she will find a beer.

On the basis of (1) and (2), I form one further belief:

- (3) Mary will decide to go in the kitchen.

TT explains the fact that I come to believe (3) by crediting me with knowledge of the folk-psychological law of practical syllogism, which states that 'if an individual, S, desires a certain outcome, O, and believes that by performing a certain action, A, she will obtain O, then S will decide to perform A'. According to TT, on the basis of belief in (1) and (2) and knowledge of the law of practical syllogism, I infer (3). Briefly, TT characterizes mindreading as a theory-based inferential process.

Let's go back to the ability to attribute disgust from CVI. A mindreader is observing a man handling a pair of dirty underwear. How does she arrive at attributing disgust to the target? Here is my proposal. The mindreader has a body of knowledge about dirty underwear. In particular, she knows that a pair of dirty underwear is a typical cause of disgust. On the basis of this knowledge, the mindreader infers that the target is undergoing disgust. To abstract from this particular case, the idea is that the ability to attribute disgust from CVI stems from knowledge about what the typical elicitors of disgust are. The passage from this idea to a TT model is straightforward. Indeed, claiming that a mindreader knows the typical causes of disgust amounts to claiming that she knows a folk-psychological law of the following form: 'if an individual, S, perceives excrement, or rotten food, or dirty underwear, etc., S will undergo disgust'. Thus, if the mindreader observes that the target is, say, perceiving a pair of dirty underwear, she can infer that the target is undergoing disgust on the basis of her knowledge of this folk-psychological law. If my proposal is correct, attribution of disgust from CVI is a theory-based inferential process.

To assess the plausibility of this TT model, we have to consider whether individuals with HD know what the typical causes of disgust are. One initial method for assessing disgust-related knowledge is considering disgust-related *verbal competence*. Sprengelmeyer et al. (1996) claimed that individuals with HD are able to produce verbal descriptions of situations under which one would experience disgust. This clearly implies that individuals with HD know what the causes of disgust are. Hayes et al. (2007), however, found that when individuals with HD were asked to verbally produce examples of situations that would typically cause disgust, they gave fewer examples than controls and produced less disgusting examples, since they usually described situations that tend to cause moral disgust rather than core disgust. On this basis, Hayes et al. concluded that knowledge about the typical elicitors of disgust is impaired in HD. Hayes et al.'s finding, however, is far from conclusive. In fact, in the same study, Hayes and colleagues showed that, when presented with words for objects that typically cause disgust (e.g., 'cockroach', 'maggot', 'excrement'), individuals with HD were able to assign these words to the disgust category. Thus, it seems that individuals with HD only have a partial deficit in verbal competence for disgust. More precisely, they have difficulties in verbally *producing* examples of disgust-provoking scenarios, but they are able to *recognize* whether a word refers to a typical cause of disgust. This strongly suggests that individuals with HD do know what the typical causes of disgust are.

A second way to test whether an individual knows the typical elicitors of disgust is to *visually* present her with examples of typical elicitors of disgust, and evaluate whether she is able to categorize them as elicitors of disgust. For my own purposes, this second procedure is more relevant, as it is crucial for my TT model that individuals with HD be able to recognize visually presented objects as causes of disgust. Again, Hayes et al. (2007) performed this test, presenting individuals with HD with pictures of typical disgust-provoking objects and scenes. *Prima facie*, the results of this experiment go against my hypothesis. Hayes et al. found that individuals with HD had difficulty in correctly classifying images that depicted typical elicitors of disgust. However, if we consider these experimental results more carefully, matters appear in a different light. Individuals with HD differed from the control population in that while the latter judged violations of the physical body (i.e., mutilations, injuries, etc.) as belonging to the 'disgust' category, individuals with HD misclassified these types of images as belonging to the 'sadness' or the 'fear' category. Individuals with HD had no problem whatsoever, however, in classifying scenes associated with animals, body products, or hygiene as disgust elicitors. For instance, *all* the patients judged an image of a cockroach crawling over leftover pizza as belonging to the 'disgust' category, and all the patients but one produced the same judgment when presented with the image of a soiled toilet. This is, of course, precisely the kind of ability one needs to have in order to classify a pair of dirty underwear as an elicitor of disgust. Accordingly, the experimental results on disgust-related knowledge in individuals with HD are consistent with my TT hypothesis that disgust attributions of the basis of CVI stem from knowing what the typical causes of disgust are.



## 7. Two Types of Mindreading

In this final section, I contrast some features of theory-based attributions of disgust from CVI with features of simulation-based attributions of disgust from facial expressions. To begin, the ability to attribute disgust on the basis of observing a disgusted facial expression is simpler than the ability to attribute disgust on the basis of CVI. I follow Goldman (2006) in asserting that face-based disgust attribution is simple in the following sense: by observing a disgusted facial expression out of context, a mindreader is able to realize that the target is undergoing a mental state *type*, that is, disgust, but she does not understand what the *intentional object* of the target's mental state is—that is, the object that the target is disgusted by. On the other hand, by observing CVI, one is usually able to understand what the target is disgusted by. This is because a fundamental component of CVI is (b), the objects in the vicinity of the target. For example, in the case that I have discussed at length, the mindreader observes that the target is handling a pair of dirty underwear. Combining this visual information with the knowledge that a pair of dirty underwear is a typical cause of disgust, the mindreader not only infers that the target is undergoing disgust, but also that the target is disgusted *by* that pair of dirty underwear. Accordingly, we can hypothesize that while face-based attributions of disgust have the form 'S is disgusted,' where 'S' should be replaced by the name of the target, attributions of disgust from CVI have the more complex form 'S is disgusted by X', where 'X' should be replaced by what the mindreader takes to be the intentional object of S's mental state.

A second kind of difference between face-based and CVI-based disgust attributions relates to the opposition between innate and acquired characteristics. There is substantial evidence that the human ability to produce and recognize facial expressions of basic emotions, including disgust, is universal and not culturally specific (Ekman & Friesen, 1989). On this basis it can be argued that the ability to recognize disgusted facial expressions is innate. On the other hand, it is implausible, to say the least, that knowing that a pair of dirty underwear is a typical cause of disgust is a piece of innate knowledge. Rather, this seems to be something that we learn empirically. The fact that at least a part of our knowledge about disgust is acquired can explain some mindreading errors. Consider this simple story. Fabio was born in Milan, and never visited any foreign countries. All the people he knows in Milan find insects disgusting. As a result, Fabio formed the belief that insects are a typical cause of disgust. One day, Fabio finally decides to visit a faraway country, and goes to a local restaurant. When Fabio notices insects in another customer's dish, he forms the belief that the customer is disgusted by those insects. But Fabio is wrong. Indeed, in that country insects are not considered disgusting. Fabio makes the mistake of considering culturally specific information to be universally held.

The innate/acquired distinction can clarify a further point. Individuals with HD do not know that disgust typically causes a characteristic facial expression. More precisely, they may know that there is some sort of facial expression associated with

disgust, but they don't know which expression it is. If they had such knowledge, they could infer on the basis of observing a disgusted facial expression that the target is undergoing disgust. One might ask why individuals with HD acquire the knowledge that certain objects typically cause disgust, but don't acquire knowledge about which facial expression is caused by disgust. The answer is as follows. Since human beings are equipped with an innate mirror-based simulational mechanism that allows them to recognize disgusted facial expressions, they do not need to have a mechanism that allows them to acquire knowledge about the characteristics of disgusted facial expressions. Unfortunately, however, when the simulation mechanism breaks down, as in HD, the affected person will lack the cognitive resources to decipher facial expressions of disgust, and will be left only with the acquired body of knowledge about the elicitors of disgust.

Finally, let's consider the following familiar argument.<sup>10</sup> TT is a descendant of functionalism in the philosophy of mind, according to which a mental state is to be defined in terms of its causal relations to sensory stimuli, other mental states, and behavioral responses—that is, in terms of its functional role (e.g., Lewis, 1972). A common objection to functionalism is that specifying the functional role of a mental state is not sufficient to capture what it is like to be in that state (Block, 1978; Jackson, 1982; Nagel, 1974). Consider disgust, for example. Critics of functionalism maintain that even if one were able to fully specify what causes disgust and what disgust in turn causes, one would still have said nothing about the experience of disgust. Now, since a Theory of Mind is constituted by a set of laws that connect sensory stimuli, mental states, and behavioral responses, it is clear that if functionalism leaves experience out, Theory of Mind does so too. So it is not easy for TT to explain how we manage to attribute experiences to our fellow human beings. This is not a minor issue, given that the attribution of experiences is a widespread business. For example, almost every time we attribute disgust to a target, we attribute a certain experience (among other things) to her. ST fares better in this respect, since it can easily account for our ability to attribute experiences. Let's consider, for instance, face-based disgust attribution. When I observe your disgusted facial expression, I: (i) simulate your experience of disgust; (ii) introspect my simulated experience of disgust; and (iii) project this experience of disgust onto you. Accordingly, I attribute an experience to you on the basis of having undergone a similar experience myself.

If we closely consider the above story about the role of simulation and Theory of Mind in attribution of experiences, we realize that individuals with HD are in a curious situation. As we know, individuals with HD are impaired in experiencing disgust, and they are thus prevented from simulating the experience. Hence, their ability to attribute disgust from CVI is entirely theory-based. But if knowing a Theory of Mind is not enough to attribute experiences, then individuals with HD are not able to attribute the experience of disgust. Thus, when individuals with HD attribute disgust to a target, they believe that she is in a certain functional state, but they have no idea of what it is like to be her.

## 8. Conclusion

ST and TT are the two most influential accounts of how mindreading works. I have argued that even a mindreading ability as narrow as attributing core disgust from visual stimuli has to be explained by invoking a blend of ST and TT. In particular, on the one hand, I have defended the idea that face-based disgust attribution is grounded in a simulation mechanism that involves a mirrored experience of disgust. On the other hand, I have shown that attribution of disgust on the basis of CVI cannot be accounted for by simulation, and should instead be explained by attributing knowledge about causal determinants of disgust to the mindreader. In sum, in order to account for the attribution of disgust from visual stimuli, we need a ST-TT hybrid model.

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## Notes

- [1] It has been claimed (e.g., Rozin & Fallon, 1987) that the substances that elicit core disgust are *contaminants*, i.e., items that cause food spoilage. According to this view, the evolutionary function of disgust is to prevent the ingestion of unhealthy foods. Other researchers (e.g., Curtis & Biran, 2001) have maintained that the adaptive function of disgust is to defend the organism against *infections*. Both hypotheses are highly interesting and deserve attention. For my present aims, however, it is unnecessary to adjudicate the controversy.
- [2] Two short comments. First, it is extremely difficult to define what subjective (or conscious) experience is, and I will not try to do so. I will content myself with saying that if a mental state has an experiential character, there exists something that it is like to be in that state. Second, philosophers use a number of different expressions to pick out what it is like to be in a mental state. For instance, they talk about 'phenomenology,' 'phenomenal character,' 'qualia,' 'subjective experience,' 'consciousness,' and so on. For sake of simplicity, from here on I will simply term what it is like to feel disgust, 'experience of disgust'.
- [3] For the distinction between core and moral disgust, see Rozin et al. (2008).
- [4] Since Goldman describes his version of ST as "a blend of ST and TT, with emphasis on simulation" (2006, p. 23), it is possible to raise the objection that his model of the ability to attribute disgust is already a ST-TT hybrid model. I am not convinced. First, Goldman is vague about how and when simulation combines with theorizing (2006, pp. 43–46). On this

point, I share Carruthers' (2006) perplexity about the way in which Goldman frames the dialectic of simulation/theorizing. That is why when I present Goldman's ST, I will deliberately focus only on the simulation component, which is, in any case, the essential component of his theory. Second, in the specific case of emotion attribution, Goldman explicitly contrasts ST with TT, and appears to be particularly dismissive of the contribution of theorizing (Goldman, 2006, pp. 119–132; Goldman & Sripada, 2005, pp. 198–201). Thus, it is highly implausible that Goldman advocates a ST-TT hybrid model of disgust attribution.

- [5] For an in-depth discussion of how to define 'simulation', see Goldman (2006, pp. 35–40).
- [6] In fact, Goldman doesn't label his own model as a model of face-based disgust *attribution*, but rather as a model of face-based disgust *recognition*. Is there a difference between recognizing an emotion and attributing it? At least in principle, there is. In fact, it is conceivable that one recognizes that a face expresses a certain emotion *without* attributing that emotion to the individual showing that facial expression. So, given that mindreading requires attributions of mental states to a target, it is at least in principle possible that a case of face-based emotion recognition is not a case of mindreading. Goldman, however, considers this abstract possibility as of little importance, since he explicitly says that he is using the expression 'recognition' in a way that "implies that the [mindreader] is not merely categorizing the emotion but also attributing it to the target" (Goldman, 2008, p. 318, fn. 5). That is, Goldman is using 'recognition' as a synonymous of 'attribution'.
- [7] To my knowledge, Goldman has taken HD into account as evidence for ST only once, and very briefly, in Goldman and Sripada (2005, p. 196).
- [8] Similar findings have been reported in Hayes et al. (2007).
- [9] This suggests that there is a third kind of disgust experience, other than the (standard) experience of disgust and the mirrored experience of disgust. This third kind, which may be labeled 'pretend experience of disgust', is, as in the mirrored experience of disgust, a simulated experience of disgust.
- [10] A somewhat similar argument was proposed in Ravenscroft (1998).

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