emotion (Magnee et al. 2007). A recent study showed that giving ASD participants a task of recognizing expressions (rather than just “watching them”) led to a comparable level of mimicry as the typical group, even though ASD mimicry was slower (Oberman et al. 2009). In short, it appears that “task engagement” is necessary to trigger mimicry in ASD individuals.

But what is “task engagement”? What factors turn on and off embodied simulation? This is not simply the question of attention and general motivation. After all, studies ensured that individuals stay “on task.” One idea is that factors like “allocentric versus egocentric perspective,” “family versus stranger,” and “emotion identification versus observation” work similarly to “eye gaze,” discussed in the target article. Specifically, all these factors switch the processing strategy from the disembodied, “pattern-matching” strategy, to one that presumably requires access to the underlying states of the individuals modeling the expressions or actions.

Of course, this idea needs to be tested directly. Here is one possibility. It is known that in perceiving expressions, ASD individuals rely more heavily on a “cold” rule-based strategy (Rutherford & McIntosh 2007). As a result, they are more likely than controls to accept as realistic the exaggerated images of expressions (smiles that are stronger than real smiles), presumably because those expressions represent “best fits” to the rule. However, this “rule-based” processing should diminish when they are dealing with faces that smile and look “at them” and are produced by family members, rather than total strangers. Importantly, the task needs to be realistically challenging – it cannot be easily solvable by a simple pattern-matching strategy (e.g., recognizing a distinct expression containing pure happiness, or a simple emoticon, like the Walmart’s smiley). Under such conditions, the embodiment (mimicry) should contribute to emotion recognition. This is critical, because as Niedenthal et al. note, mimicry contributes to performance of typical participants only when the perceptual task is hard, the participant cares, and the subjective emotional response is a useful signal for the recognition task (Oberman et al. 2007).

I hope that this exchange inspires fruitful research that will benefit not only theoretical understanding of emotion processing, but also better research on atypical social functioning (see Winkielman et al. [2009] for further discussion).

Authors’ Response

The future of SIMS: Who embodies which smile and when?

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Paula M. Niedenthal,a Martial Mermillod,a Marcus Maringer,b and Ursula Hessc

*Centre National de la Recherche Scientifique (CNRS) and Clermont Université, 63037 Clermont-Ferrand, France; aDepartment of Psychology, University of Amsterdam, 1018 WB Amsterdam, The Netherlands; bDepartment of Psychology, Humboldt-Universität Berlin, 12489 Berlin, Germany. niedenthal@wisc.edu http://wwwpsy.univ-bpclermont.fr/~niedenthal/ martial.mermillod@univ-bpclermont.fr http://wwwpsy.univ-bpclermont.fr/~mermillod/ m.maringer@rug.nl Ursula.hess@psychologie.hu-berlin.de http://www.psychology.hu-berlin.de/staff/1683737

Abstract: The set of 30 stimulating commentaries on our target article helps to define the areas of our initial position that should be reiterated or else made clearer and, more importantly, the ways in which moderators of and extensions to the SIMS can be imagined. In our response, we divide the areas of discussion into (1) a clarification of our meaning of “functional,” (2) a consideration of our proposed categories of smiles, (3) a reminder about the role of top-down processes in the interpretation of smile meaning in SIMS, (4) an evaluation of the role of eye contact in the interpretation of facial expression of emotion, and (5) an assessment of the possible moderators of the core SIMS model. We end with an appreciation of the proposed extensions to the model, and note that the future of research on the problem of the smile appears to us to be assured.

R1. Introduction

One of the problems with researching smiles in humans is that humans use language that communicates their complex causal attributions for smile behavior, and thus for its meaning. This fact, we believe, has strongly influenced the history of the scientific study of the smile in social psychology. This fact has also led us astray in some ways. The prime example of a complex attributional judgment is that a smile is “false” (versus “true”). The spontaneous use of these labels by observers has strongly influenced the course of social psychological research on the smile. Yet, even though researchers can create stimuli in the laboratory that have the properties of smiles that are labeled, perhaps even quite universally in laboratory experiments, as “true” versus “false,” (or more or less genuine) it is probable that these are not the expressions occurring in daily life that are judged “true” and “false.” Hence, we agree strongly with Fernández-Dols & Carrera that the “true” versus “false” distinction is not the best way to carve up the smile landscape (see also Hess & Kleck 1990). Bouissac clearly agrees with this point.

Indeed, when Ekman and Friesen first studied the importance of the Duchenne marker (e.g., Ekman & Friesen 1982), they defined as “false” smiles the expressions made by individuals who were effortfully trying to deceive. Specifically, the individuals whose smiles were ultimately the subject of study were trying to cover up distress in response to an anxiety-producing film or situation, with the goal of convincing perceivers that they were actually experiencing positive affect. When individuals were engaged in this deception, there was little evidence of the Duchenne marker. Ekman et al. (1990) further showed that EEG recordings of individuals who expressed non-Duchenne smiles revealed evidence of negative affect or of conflict (Wacker et al. 2010). In any event, the conclusion was that smiles called “false” were sometimes associated with the subjective experience of negative affect in the smiler.

But there would probably be no agreement about the attributed causes of “true” and “false” universally. In recently collected cross-cultural data, one of our North American female respondents reported that even if she is having a bad day when at her job, she wants people to feel good, and so she smiles. Is this a false smile or a true smile? It is false in so far as it does not reflect how she “feels in general today,” and so perhaps some individuals or cultures would call her smile “false.” But it is true in that she has a positive social motivation. She thinks those smiles are “true.”

Lurking under the “true” and “false” distinction are therefore three plausible categories of attribution upon
which the judgment relies: the feeling state of the smiler (positive, neutral, negative), the intended outcome of the smile interaction for the smiler (positive, neutral, negative) and the intended outcome of the smile interaction for the perceiver of the smile (positive, neutral, negative). The relative weight of each of these dimensions in determining the judgment that a smile is "false" versus "true" probably varies across culture. Our instinct, based on responses to some of our open-ended questions, is that in North American culture the attribution that the smiler intends harm to the perceiver of the smile is the dominant information that drives the "false" judgment. However, in other cultures, perhaps in Europe, attributions based on other dimensions are also likely to be equal grounds for the judgment of "false."

So, all we really know about the terms "true" and "false" as regards smiles, is that they are used. We also know that we can construct smiles that look more or less true and false, and receive those of meaning judgments judgments. But we do not know more than that, and perhaps that is not the best way to go. Indeed, the SIMS was not developed to distinguish between the type of person or culture that would judge a smile to be "true" or "false." That is what our own cross-cultural data collection is about. The SIMS model is an attempt to define the behavior and brain processes that support certain general classes about smiles. As regards the judgment that a smile is "false" in the core model, we argued that dominance smiles are not likely smiles of positive affect; and so, depending upon the culture, the simulation of a dominance smile may usually support a judgment of "false" (i.e., in particular, when the judgment scale that is used is a scale of "authenticity" or "genuineness"). But any attention we paid to the "true" and "false" distinction was meant to lend coherence to the literature. As stated, we believe that a different approach to carving up the smiles space is more useful, and that is why we promote a functional account of smiles. A parallel semantic analysis would yield the most convincing knowledge base, of course (as suggested by Bouissac).

R2. Functional arguments

Our ethologist commentators such as Mehu & N'Diaye, Ohala, as well as Sauter & Levinson and Centorrino, Djemai, Hopfensitz, Milinski, & Seabright (Centorrino et al.), contest in different ways our use of "functional" language in defining the three major smile types of interest to the SIMS. They also bemoan our lack of data (so do we, but we are working on it). It is therefore our burden, first, to define "functional" in our account. Further discussion of our typology follows in section R3.

For ethologists, functional is synonymous with "adaptive." But it is also the case that the discussion of the relationship between function and form, among ethologists and evolutionary theorists, is not settled or consensual. The debate is, in fact, a quite lively one (e.g., Allen & Bekoff 1995; Ovren & Rendall 2001). We are aware that it is reckless to make functional (i.e., adaptive) arguments about any species that is living in a habitat in which it did not evolve, such as human beings living in suburban environments (Moffatt & Nelson, 1992). Hence, we have been most influenced by emotion researchers who use the language of functionalism in a way that is relevant to humans and was initially motivated by responses to the idea that emotions disrupt reason and are generally harmful psychological events (Niedenthal et al. 2006). These researchers include Frijda, Scherer, Oatley, Fischer, Haidt, Tracy, and Keltner, among many other modern emotions researchers.

These researchers' definition of function with regard to emotion and emotional expression is consistent with Keltner and Gross (1999) or Scherer (1987), who hold that emotions are solutions to problems and opportunities related to physical and social survival. Those authors further state "Functional ascriptions, therefore, refer to the history of a behavior, trait, or system, as well as its regular consequences that benefit the organism, or more specifically, the system in which the trait, behavior, or system is contained" (Keltner & Gross 1999, p. 469).

Social functionalist accounts propose specifically that two very important challenges for human survival include (1) attachment to caretakers and potential mates, and (2) integration into groups. Another important challenge is the establishment and maintenance of social hierarchies. The assumptions are that human survival depends upon group membership and that long-term group functioning requires effective leadership (Keltner & Haidt 1999). The importance of the smile as a foundational social glue used in the solution of these problems is made even more precisely by some of our own commentators. For example, as Swain & Ho note, the baby's smile is a highly physiologically rewarding stimulus to a parent. It helps the parent hang in there. Additional research, reported by Swain and colleagues (e.g., Lenzi et al. 2009; Strathcarn et al. 2009; Swain 2008), provides even more information about the circuits by which the brain supports responding to attachment objects in particular.

A social functional account does not shun comparative psychology or ethology, however, and we rely on it for our account of the landscape of the human smile. Indeed, as de Waal (2003) has suggested, Darwin was on to something when he focused on facial expression of emotion as a good candidate test of his evolutionary theory. Along with de Waal, we consider the primate and comparative psychology literatures to be useful for motivating our distinction among smiles as conforming to enjoyment smiles, affiliative smiles, and dominance smiles (noting that these are names for expressions that yield classes of human attributional judgments that can be summarized as reflecting enjoyment, affiliation, and dominance).

R3. Our smile typology

But there are a number of conceptual problems to be resolved, especially about the proposed category of dominance smiles. Some of those issues require collaboration with ethologists. One question has to do with the evolution of displays of teeth in primates and the role of teeth display in human smiles. There has been confusion in this regard because of the initial reliance on the study of rhesus macaques, which have a strong linear, hierarchical societal structure. Referring to Darwin, de Waal (2003) writes:

For example, he noted that the bared-teeth expression ... by a black Sulawesi macaque, occurs when the animal is pleased to
be caressed. Retraction of the lips to expose both rows of teeth is indeed a relaxed, friendly expression in this species as opposed to the same expression in most macaques, in which it signifies submission. How do we know this? Quantitative analysis of natural social interaction sequences among Sulawesi macaques demonstrates that the bared-teeth display predicts the onset of affiliative contact between sender and addressee, hence that it likely is associated with a positive social attitude. In these macaques, teeth-baring often occurs mutually between individuals. In the better known rhesus macaque, in contrast, teeth-baring is given exclusively by subordinate to dominant individuals – hence never mutually – and is a common response to threats and intimidations. The colloquial term “fear grimace” for all teeth-baring expressions derives from the familiarity of researchers with the rhesus monkey – the most common laboratory primate in the West – rather than from a comprehensive look at the primate order, in which this expression has a variety of meanings. (de Waal 2003, p. 10)

One of the important points and reasons for quoting this passage at length is to note that the use of teeth in a gesture such as the smile, and therefore the meaning(s) of the smile, varies even within closely related primates and depends upon the type of social structure in which they live. We can be motivated by this comparison, noting that the showing of teeth in the gesture called the smile is very complex. This variation exists even across human cultures. For instance, some Asian cultures teach the covering of the teeth during smiling and laughing whereas other cultures do not.

The possibility that the same expression, such as the smile or the laugh, can have different meanings across and within cultures is further expressed by this quote:

The laughing expression of apes is clearly homologous with that of our own species: the laugh derives from a widespread mammalian play expression. As we have seen, however, homology does not necessarily imply that the expression functions in the same way in all hominoids (i.e., humans and apes). In bonobos and chimpanzees laughing is closely tied to play and affiliative interaction. Playful interaction is obviously range of circumstances. Playful interaction is obviously

The three categories of laughter conform to our own typology for the smile. Furthermore, we suggest that the relationship between laughing and smiling in humans may be a closer one than it is for other primates. Indeed, there may be a relationship between the human smile and the show of teeth as in threat, as suggested by Ohala; however, it seems likely, as we think may be implied by the previous quote, that the different human smiles have their basis in laughter (which also shows teeth). This does not deny the possibility, discussed by Liu, Ge, Luo, & Luo (Liu et al.), that some cultures hide the teeth possibly to avoid miscommunication of threat or else a violation of an undesired association to animals.

Among the many ways of validating this smile typology, we have recently begun a reanalysis of data collected for other theoretical purposes (Deborah Prentice, personal communication). The experiments in which the data were collected involved the presentation of norm-conforming and norm non-conforming oral statements by individuals who were ostensibly peers (students at the same university) of the participants. As the participants listened to the norm conforming and non-conforming statements, their faces were recorded by video, and four facial muscles were recorded with electromyography techniques. In addition to measures of the face, measures of the participants’ moods and their reactions to the peers whose comments they were listening to were also taken. One of the most striking things is that when listening to both conforming and non-conforming statements, participants smiled. The difference was that their perceptions of the non-conforming peers were negative. Their smiles were smiles of derision, not affiliation. We can test this impression by relating the use of specific muscles to the feelings and the judgments of the participants to ask whether individuals smile both out of affiliation and superiority and whether those smiles have different properties. Maybe different muscles are employed, and maybe the body is used differently (which we can code from the videos).

Evaluating the characteristics of smiles associated with judgments of enjoyment, affiliation, and dominance, will force us to push the SIMS to be more specific in its statements of the brain systems that ground smile meaning of course. In their commentary, Mann & Choe argue that, although SIMS holds that the meaning of smiles can be grounded in embodied simulation, it is not specific enough about which sensory-motor systems ground the meanings of smiles (a related argument is presented by Chang & Vermeulen). Mann & Choe propose that, although some meaning can be captured by the facial sensory-motor system, important aspects of smile meaning cannot be captured without grounding smiles with respect to high-level actions making up the behavioral context.

Mann & Choe indeed suggest an interesting way to ground the meaning of smiles in higher-level actions of the perceiver of the smile. They propose that when a perceiver sees an enjoyment smile, the objective is to maintain the enjoyment smile (maintain sensory invariance), for instance, by telling a joke. The meaning of a smile can then be grounded in the (higher-level) actions of the perceiver, which maintain the smile in the sender. In our target article, we focused mainly on the affective feedback of the facial sensory-motor system as a consequence of facial simulation. In that case, the meaning of the smile is grounded in the affective output of the simulation. In addition, we argue that the meaning of a smile can be grounded in the social and behavioral context in which a smile occurs. For example, a smile shown by a salesclerk who tries to sell a pair of shoes is seen as less genuine compared to a smile that is shown by a person who just sold a pair of shoes (Mingier et al., in press). Hence, similar to what Mann & Choe propose, we do argue that the meaning of smiles can be grounded in high-level actions of the sender (rather than the perceiver). Sensory invariance in this case might relate to the different contexts and behaviors that are likely to be accompanied by similar facial expressions. In this way, the commentary by Mann & Choe has extended our link between meaning of smiles and behavioral context of the sender to the link between meaning of smiles and the behavioral context of the perceiver. We believe that both behaviors (perceiver’s and sender’s behaviors) can be used to ground meaning of facial expressions.

Along with refining and validating the smile typology, it will be pertinent to specify the nature and role of
er, is a factor that determines the type of processing that grounds judgments of smile meaning. Individuals may devote more resources to understanding those with whom they have an intimate or interdependent relationship (e.g., Zajonc et al. 1988). But a rigorous and theoretically concise account of why that is so will be required. One avenue is to integrate some of the insights from the commentary by Vigil & Coulombe, particularly as regards the role of attachment in these processes. We do note that according to Vigil & Coulombe our central claim is that “simulative sensitivities modulate the autonoemic representation or epistemic ‘meaning’ of other people’s facial expressions”; however, we would not articulate the central claim of our target article in that way as the statement only addresses a small part of the model. Furthermore, like Winkielman, we do believe that the role of mimicry in interpreting the meaning of facial expression has received some impressive supportive evidence (e.g., from Maringer et al., in press; discussed earlier and in the target article).

R5. What is it about eye contact?

Aside from our proposed functional categorization of smiles and its links to social-attributional judgments, the idea that eye contact has developed as a developmentally
basic and subsequently sufficient trigger of embodied simulation gave rise to the most energetic discussion. There is much to work on here.

Senju & Johnson, for instance, have suggested that the SIMS model be integrated with their fast-track modulator (FTM) model. The FTM model holds that eye contact is mediated by a subcortical face detection pathway hypothesized to involve the superior colliculus, pulvinar, and amygdala (Senju & Johnson 2009). The root of this subcortical pathway is assumed to be constituted of alpha ganglion cells, at the origin of magnocellular layers and LSF subsequent cortical pathways, which are very fast but provide only low spatial frequency (LSF) visual information. This subcortical pathway has been confirmed for auditory information (Campeau & Davis 1995; Doron & Ledoux 1999) and visual information (Doron & Ledoux 1999; Linke et al. 1999; Shi & Davis 2001) in rats.

Concerning humans, different studies suggest the existence of a preferential link between LSF information and the emotional system, particularly threat detection. This plausible preferential link was obtained on the basis of neuroimaging (Morris et al. 1999; Pourtois et al. 2005; Vuilleumier et al. 2003), neural-network modeling (Mermillod, in press a; Mermillod et al. 2009), and behavioral experiments (Bocanegra & Zeelenberg, 2009; Holmes et al. 2005; Mermillod et al., in press b). However, whereas these studies hint at a preferential link between LSF visual information and emotional processes, possibly occurring at the level of the amygdala, they do not constitute formal evidence for the subcortical pathway assumed in Ledoux’s (1996) model. Therefore, it is speculative to incorporate this pathway in the SIMS model at this time.

However, this is obviously a very interesting way to develop the SIMS model and, more specifically, the complementarities between fast and automatic processes of relevant emotional stimuli in the environment, potentially operating at the level of subcortical structures and more complex associative processes occurring at the level of cortical areas. The interesting contribution of the FTM model is that it specifies the relationship between early visual processes and subsequent emotional processes related to eye contact. This link between perception and emotions should therefore be investigated.

Similarly, the question of automatic and unconscious response to eye gaze was raised by Chatelle, Laureys, Majerus, & Schnakers (Chantelle et al.) with regard to severely brain-injured patients. These commentators propose that minimally conscious state (MCS) patients could be differentiated from vegetative state (VS) patients based on eye gaze. They propose that intentionality and different level of consciousness could be assessed though eye gaze. For our model, this raises the question of the consciousness of different level of processing. In relationship with the previous comment proposed by Senju & Johnson, we suggest the possibility of a direct, automatic, but also unconscious subcortical pathway for eye gaze orientation. This hypothesis can be supported by research on emotional blindsight (de Gelder et al. 1999; Peigné et al. 2004), showing that hemianopic patients might be able to detect emotions presented in their blind visual field above chance (de Gelder et al. 1999). An important point is that these patients are not conscious of this blind perception and feel that they respond at chance level. In other words, this subcortical pathway (if it exists) seems to operate beyond the scope of consciousness. Combining this finding with the FTM model (Senju & Johnson 2009), we can assume that automatic but uncontrolled eye gaze direction could be directed by subcortical structures like the superior colliculus, the pulvinar, and possibly the amygdala for automatic responses to environmental stimuli in VS patients, whereas MCS patients might be able to use more neural resources involving cortical and other subcortical structures. As suggested by Chatelle et al., we believe that investigation of the neural underpinnings of directed versus automatic eye gaze in VS versus MCS patients could be a very interesting way to investigate the neural basis of consciousness.

Finally, as highlighted by Chakrabarti’s comments, a model of smile perception involving the question of eye contact necessarily raises the question of parsimony. More than 30 emotional states can be associated with smiles (Golan & Baron-Cohen 2006), and it would be rather implausible to associate one neural module per type of emotional feeling. The goal of the SIMS model, however, was to propose general principles, associated with different neural pathways, to account for the emotional processing of smiles. We hope that this parsimonious approach, based on scientific evidence in support of our new theoretical framework, will be able to account for the larger set of empirical data relating to smiles. Among them, and as proposed by Chakrabarti, we will have to determine whether not only does eye contact act as a trigger for subsequent amygdala activity, but, conversely, amygdala activity can boost the search for relevant social cues and, therefore, eye contact. Chakrabarti also raises the question of determining whether embodied simulation processes are emotion specific. The SIMS model focuses on smiles, but as noted in the target article, we assume that similar processes are likely to occur in the recognition of other emotional expressions.

R6. Moderators and individual differences

The SIMS model was developed with the goal of defining general processes by which individuals attribute meaning to a smile. In particular, the model highlights the role of eye contact, mimicry, and the induction of specific brain states. However, along with our commentators, we encourage discussion of the potential impact of individual differences. Foremost amongst these are the differences of gender and culture, as emphasized by several commentators (Bouissac; Caldara; Grézes, & Sander; Conty et al.; Liu et al.; and Simpson & Fragaszy).

The current development of the SIMS model does not discuss those influences in detail, even though we specifically note that “it is essential to note that cultural differences may modulate our account.” Clearly, we agree with the notion that individual differences have a role to play and can be expected to moderate some of the processes we discuss. As Covas-Smith, Fine, Glenberg, Keylor, Li, Marsh, Osborne, Soliman, & Yee (Covas-Smith et al.) note, cultural differences in eye contact preferences should entrain differential predictions based on the SIMS model. The question then arises—do we know enough about these differences to accurately predict their effect? And here the issue becomes rather
more complex. **Caldara** provides evidence that members of collectivist cultures fixate faces around the nose area — that is, do not actually seek full eye contact. By contrast, Yuki et al. (2007) note that Japanese participants weigh eye information more heavily than mouth information, and similar data are reported by Liu et al. as being under review. Just this short summary of data presented in the commentaries shows that at this point we may not be able to predict the impact of culture on eye gaze and, consequently, on its role for smile interpretation. What is needed are intercultural studies focusing not only on emotion decoding accuracy but also more precisely on the process of interpreting facial expressions. The SIMS model provides a framework for such research.

For example, Hess and Kirouac (2000) have proposed that when individuals do not know each other, they tend to resort to stereotype knowledge about social group members when decoding facial expressions. We have already considered whether this is a general rule or whether this fact indeed varies across culture; and how this fits with the SIMS. One of our major cultural hypotheses relates to the processing of in-group versus out-group facial expressions (e.g., Niedenthal & Maringer 2009). The foundational history of some societies — sometimes called “settler societies” where the focus is on the fact that a land occupied by an indigenous peoples was taken over and settled by people from other cultures and nationalities — may strongly influence the key behaviors of SIMS.

The other individual difference highlighted by commentators is that of gender differences (Simpson & Fragarzy). Should we expect embodiment to play a different role for men and women? Simpson & Fragarzy point out that there are differences between men and women in emotion recognition accuracy in some studies and these are positively correlated with looks to the eye (Hall et al. 2010). They also note that women who have been given testosterone show reduced mimicry (Hermans et al. 2006). In fact, a number of top-down processes, such as motivation and the observers’ own beliefs and values, are likely to modulate behaviors linked to mimicry and contagion (Hess & Fischer, under review). In this context it is also interesting to note that men and women differ in their capacity for interoception (e.g., Harver et al. 1993); and it has been suggested that women are more likely to base at least the perception of their own emotions on social context cues than men are (Pennebaker & Roberts 1992). This opens the door to the possibility that women may also use social context cues and emotion knowledge to a larger extent when considering the meaning of smiles. These issues are certainly important and should be investigated in the framework of the SIMS model. Yet, the factors discussed above only affect quantitative aspects of the process and do not require the addition of new processes into the SIMS model.

**R7. Extensions**

Some of our commentators have suggested ways to push SIMS as we engage in the process of testing and refining the model (Alibali & Hostetter; Bartlett; Basso & Oullier; Bribiño, DeMarree, & Smith [Bribiño et al.]; Kiverstein & Zamuner).

For instance, Bartlett argues for the need to consider time. By “time,” she means that part of the development of a complex model that integrates behaviors and multiple brain circuits involves a specification of the timing of these interactions and the neural activations. Silvan S. Tomkins was an early advocate of the notion that emotions are defined in part in terms of the timing of their onset and their duration (Tomkins 1962; 1963). These temporal components constitute the very form of the emotion. We agree that timing principles will be an important part of the model and that timing gone awry will be at the basis of dysfunction in emotional information processing.

Another extension is proposed by Alibali & Hostetter, and also by Basso & Oullier, who point to the fact that emotions are also expressed in gesture and in the voice. Embodied simulation of these parts of emotional experience will also play a role in emotional information processing per se and will interact with the simulation, and therefore, the understanding of facial expression. Different weights and roles of the many cues to emotion can in part be determined by examining the cases of mismatch between one (facial expression) and the other (emotional gesture). Another important question will be why emotion is communicated often in more than one expressive channel. Why do we have emotional gestural and prosody if we already have the exquisitely nuanced face? We feel that the SIMS model presents a valuable framework for the study of these and other pertinent processes.

**NOTE**

1. An intended negative outcome for the smiler would be unusual and probably related to a non-typical state, as one smiles before committing an act that one knows will be punished or will lead to self-harm.

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[The letters “a” and “e” before author’s initials stand for target article and response references, respectively.]


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