faces with an averted gaze may be considered to be more ambiguous than happy faces with a direct gaze, causing them to elicit less emotion, or ambivalent emotion. In support of this, studies show that when the approach/avoidance motivation of the gaze direction matches the approach/avoidance motivation of the emotion expression (e.g., when happy and angry faces are presented with a direct gaze, and sad and fearful faces are presented with an averted gaze), the emotion is identified more quickly (Adams & Kleck 2003; 2005), and the perceived emotional intensity of the expression also increases (Adams & Kleck 2005). These results with happy and angry faces are consistent with the SIMS model. However, the model assumes that similar processes should underlie the simulation of all types of expressions, and thus it cannot account for why sad and fearful faces should be identified more quickly, and considered to be more emotionally intense, when presented with averted rather than with direct gazes.

The SIMS model represents an ambitious integration of social, cognitive, and neuro-psychology. However, one aspect that needs to be clarified is whether simulation operates similarly for different types of smiles, such as true versus false smiles, and smiles associated with physical markers versus more ambiguous smiles. It also remains to be demonstrated whether simulation is indeed critical for the interpretation of smiles, or whether physical and contextual cues play a greater role in this process. Nevertheless, the model raises many testable hypotheses, which provide a fruitful starting point for exploring the contribution of simulation to the processing of facial expressions.

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Eye gaze and conscious processing in severely brain-injured patients

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Abstract: Niedenthal et al. discuss the importance of eye gaze in embodied simulation and, more globally, in the processing of emotional visual stimulation (such as facial expression). In this commentary, we illustrate the relationship between oriented eye movements, consciousness, and emotion by using the case of severely brain-injured patients recovering from coma (i.e., vegetative and minimally conscious patients).

The vegetative state (VS) is characterized by a preserved arousal level but also by the absence of any sign of consciousness of the environment and of oneself (e.g., absence of oriented responses to environmental stimulation) (The Multi-Society Task Force on PVS 1994). The patient in a minimally conscious state (MCS), on the contrary, demonstrates inconsistent, basic but reproducible signs of consciousness of the environment and of oneself (e.g., oriented responses to environmental stimulation suggesting an interaction between the patient and his/her surroundings) (Giacino et al. 2002). Both populations may be particularly useful for studying the concept of consciousness via the progressive recovery of the most primary aspects of consciousness, and the behavioral and cerebral correlates that accompany them.

Niedenthal et al. discuss the importance of eye gaze in embodied simulation and, more globally, in the processing of emotional visual stimulation (such as facial expression). Eye gaze involves interaction between the subject and his/her surroundings. At a neurobehavioral level, oriented eye movements are usually associated with conscious processing (Giacino et al. 2002). MCS patients are able to track a person moving in front of them, whereas VS patients are not. Only MCS patients can therefore detect emotional visual stimuli present in their surroundings. According to a recent study, visual pursuit is more frequently detected in response to emotional stimulation (e.g., the appearance of one's face in a mirror) than to non-emotional stimulation (e.g., a person moving) (Vanhaudenhuyse et al. 2008).

MCS patients also show more complex emotional responses than VS patients. For instance, VS patients may smile or grimace, shed tears, or make grunting or groaning sounds, but for no discernible reason (The Multi-Society Task Force on PVS 1994; Working Party of the Royal College of Physicians 2003), similarly to what can be observed in anencephalic infants lacking a functional neocortex (Massimelli 2007). MCS patients can manifest appropriate smiling or crying in response to specific linguistic or visual content of emotional stimuli, suggesting an appropriate interaction between the patient and his/her environment (Giacino et al. 2002). Here, consciousness is reflected by the presence of basic but contingent social and emotional behaviors, those requiring a complex cortical activity. Using auditory (Laureys et al. 2000) and noxious stimuli (Boyl et al. 2008; Laureys et al. 2002), previous studies in functional neuroimaging have shown that, while brain activation isolated to primary cortices is observed in VS patients, an activation in associative areas as well as preserved functional connectivity between cortico-cortical areas (i.e., between primary and associative cortices) is observed in MCS patients (see our Fig. 1). MCS patients seem, therefore, to present a more complex social and emotional pattern at a behavioral level and a more integrative brain processing than VS patients.

Even if oriented eye movements, such as visual pursuit, are usually considered a sign of consciousness, controversies remain concerning visual fixation. Visual fixation includes eye gaze and can be described as the eyes changing from their initial fixation point and refixating on the new target location (Giacino et al. 2004). As eye gaze involves interaction between the subject and his/her surroundings, visual fixation would have to be considered as a sign of consciousness. However, whereas the Aspen Workgoup considers this behavior as a sign of consciousness (Giacino et al. 2002), the College of Physicians considers its presence as reflecting a reflexive activity (Working Party of the Royal College of Physicians 2003). Using active paradigms (i.e., the patients were asked to mentally perform a task), voluntary brain activity has been obtained in patients showing mainly low-level behavioral responses such as visual fixation, suggesting it may be a sign of consciousness (Owen et al. 2006; Schnakers et al. 2008). However, we have recently shown no differences in brain activity and connectivity in VS patients presenting or not presenting visual fixation, suggesting that it does not necessarily reflect consciousness and higher-order cortical functioning (Bruno et al. 2010). According to these results, it is not clear whether visual fixation reflects conscious interaction between the patient and his/her surroundings.

In conclusion, consciousness level is associated with social and emotional behaviors of different complexity. Conscious patients (i.e., MCS) show high-level behavioral responses and brain activation as compared to non-conscious patients (i.e., VS). Nevertheless, the particular case of visual fixation would have to be further investigated in order to better define its relationship to consciousness.

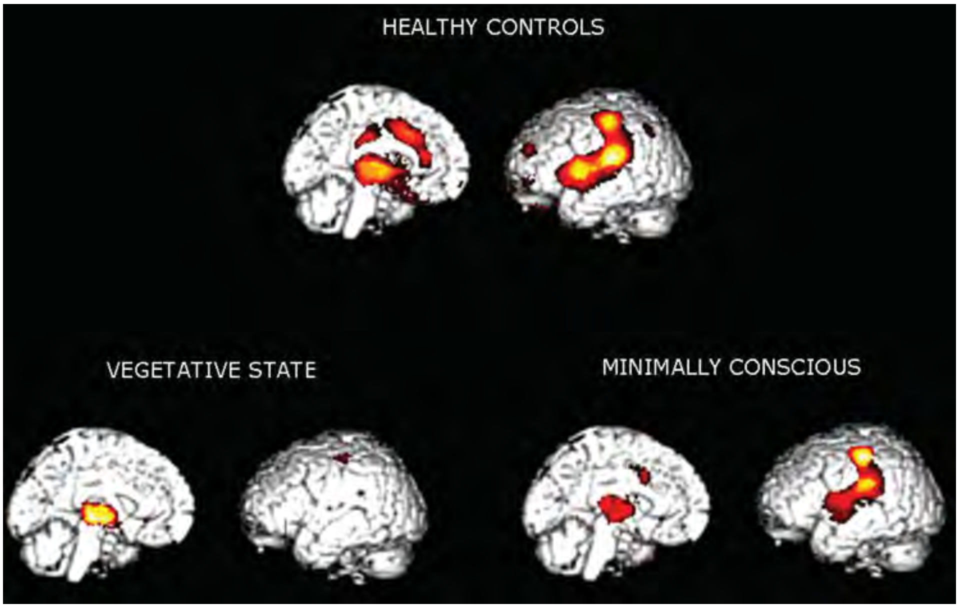

Figure 1 (Chatelle et al.). Cerebral activation to noxious stimulation. In the darker brain regions (which appear in red in the online version, available at www.journals.cambridge.org/bbs) that activated more during noxious stimulation in healthy controls (top), in vegetative state (bottom, left side) and in minimally conscious state (bottom, right side) as compared to rest (adapted from Boly et al. 2008 and Laureys et al. 2002).

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How does perceiving eye direction modulate emotion recognition?

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Abstract: Niedenthal et al. postulate that eye contact with the expresser of an emotion automatically initiates embodied simulation. Our commentary explores the generality of such an eye contact effect for emotions other than happiness. Based on the appraisal theory of emotion, we propose that embodied simulation may be reinforced by mutual or averted gaze as a function of emotional context.

We congratulate Niedenthal et al. for their outstanding contribution to both empirical and conceptual approaches in psychology and neuroscience. As reported by the authors, smiling faces are judged happier when gazing at the participant as compared to gazing sideways (e.g., Adams & Kleck 2005). The authors advance that such an increase in positive intensity could reflect a particularly accurate embodied simulation during smile perception. Here, we explore whether such a model could account for recognition of all emotions. Alternatively, the triggering function of eye contact may be specific to a subset of emotions that includes happiness.

Although facial expressions are efficient emotional signals, eye gaze direction is important for signaling the referent of an expression and, therefore, the attended object of the elicited emotion (George & Conty 2008). Converging evidence suggests that these two signals are integrated during the perception of facial emotion. Further, behavioral studies have reported that the perception of facial expressions can be modulated by eye-gaze direction. However, the effect of gaze on emotion recognition depends on the type of expression. For example, it has been shown that angry faces are perceived to express more anger with direct than averted gaze, whereas fearful faces are perceived to express more fear with averted than direct gaze (Adams & Kleck 2003; Sander et al. 2007). These results can be explained within a self-relevance framework (Sander et al. 2003). Indeed, it has been proposed that angry expressions with averted gaze or fearful expressions with direct gaze have less relevance for oneself than these expressions with a direct or averted gaze, respectively. The rationale is that the aversive dimension of anger is higher when one is the target of it (and hence gazed at); similarly, the threatening content of fearful expressions is higher when the face is looking away from the observer, as the object of fear for another agent can also reflect a potential menace for the observer. So far, these results suggest that emotion perception is influenced by the self-relevance of expression based on gaze direction, and this process appears to be emotion-dependent.

Niedenthal et al. propose that the amygdala may produce states that further contribute to simulations that underlie how smiles are interpreted. A recent brain imaging experiment is particularly relevant to this view and the prediction for the role of gaze contact in the processing of happiness: Sato et al. (2010) showed that dynamic happy faces elicit more amygdala activation when gazing at – as opposed to away from – the observer. Yet, the amygdala does not always show greater response to direct as compared to averted gaze for all emotions, but rather supports its involvement in the appraisal of self-relevance (N'Diaye et al. 2009). Brain-imaging and patient studies suggest that the amygdala deals with the integration of emotional expression and gaze direction (Conty et al. 2010; Cristinzio et al. 2010), with typical differential amygdala activity for anger *versus* fear processing as a function of direct *versus* averted gazed (Adams et al. 2010; Hadjikhani et al. 2008; Sato et al. 2010). Therefore, amygdala responses to a