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Intentional action processing results from automatic bottom-up attention: An EEG-investigation into the Social Relevance Hypothesis using hypnosis

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A B S T R A C T

Social stimuli grab our attention. However, it has rarely been investigated how variations in attention affect the processing of social stimuli, although the answer could help us uncover details of social cognition processes such as action understanding. In the present study, we examined how changes to bottom-up attention affects neural EEG-responses associated with intentional action processing. We induced an increase in bottom-up attention by using hypnosis. We recorded the electroencephalographic μ-wave suppression of hypnotized participants when presented with intentional actions in first and third person perspective in a video-clip paradigm. Previous studies have shown that the μ-rhythm is selectively suppressed both when executing and observing goal-directed motor actions; hence it can be used as a neural signal for intentional action processing. Our results show that neutral hypnotic trance increases μ-suppression in highly suggestible participants when they observe intentional actions. This suggests that social action processing is enhanced when bottom-up attentional processes are predominant. Our findings support the Social Relevance Hypothesis, according to which social action processing is a bottom-up driven attentional process, and can thus be altered as a function of bottom-up processing devoted to a social stimulus.

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1. Introduction

Attention plays a key role in most domains of cognition, but it seems to be especially attuned to identify social stimuli. A large body of evidence supports this observation: human infants inherit an attentional preference for social stimuli such as faces (Gliga, Elsabbagh, Andravizou, & Johnson, 2009), we quickly attend to human faces and bodies in naturalistic scenes (Fletcher-Watson, Findlay, Leekam, & Benson, 2008), social stimuli have a higher probability to automatically break through

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conscious awareness than non-social stimuli (Jiang, Costello, & He, 2007), and direct eye-gaze easily captures attention by both children and adults (Senju & Johnson, 2009) – just to name few examples.

Although a complete dichotomous separation of top-down and bottom-up attentional processes is not possible – since they seem to interact with each other in most cognitive tasks (Egeth & Yantis, 1997; Sarter, Givens, & Bruno, 2001; but note Firestone & Scholl, 2015) – we can still ask whether we process social stimuli such as intentional actions in a way that is predominantly guided by automatic, bottom-up processes (cf. also Cook, Barbalat, & Blakemore, 2012). Broadly, automatic bottom-up processes are those processes that are obligatory, and hard to ignore, suppress or alter (Shiffrin & Schneider, 1977).[1] An attempt to answer that question is captured by the Social Relevance Hypothesis (SRH) (Oberman, Ramachandran, & Pineda, 2008). According to SRH, various capacities in social cognition crucially depend on social stimuli being automatically assigned a high degree of attentional relevance.

SRH has been mainly used to understand Autism Spectrum Disorder (ASD). For example, Oberman et al. (2008) argued that the "dysfunction reported in individuals with ASD may be the result of lack of social relevance [for them] in the stimuli used". According to SRH, the low performance of ASD patients in certain social tasks could be due to problems in the way their attention latches on to social stimuli, rather than in their social competence per se. Chevallier, Kohls, Troiani, Brodkin, and Schultz (2012) also defend SRH mainly in the context of ASD. They point out that, because social interactions and cooperative behavior lead to important fitness benefits, social stimuli are automatically prioritized. According to their theory, this social attention system is malfunctioning in ASD patients, and impedes performance in subsequent social tasks and processes.

Support for this causal relation came from experiments investigating the pattern of the EEG μ-rhythm in ASD patients. The μ-rhythm is an EEG rhythm recorded over sensorimotor cortices that oscillates in the alpha (8–12 Hz) and beta (15–25 Hz) frequency band (Hari, 2006; Pineda, 2005). Recent evidence furthermore suggests distinguishable subcomponents of the μ-rhythm in the lower and upper alpha range (Dumas, Soussignan, Hugueville, Martinerie, & Nadel, 2014; Sebastiani et al., 2014). The μ is selectively suppressed when intentional actions are *performed* or *observed* by an agent, which is thought to reflect event-related desynchronization of motor cortices (Hari, 2006; Pineda, 2005). Due to its functionally related oscillation pattern, the μ is commonly assumed to index intentional action processing (Hari, 2006; Kilner, Marchant, & Frith, 2006; Oberman et al., 2005; Perry & Bentin, 2009; Perry, Stein, & Bentin, 2011; Pineda, 2005). Oberman et al. (2005) found that ASD patients showed a clear suppression of the μ when they themselves executed motor actions, but lacked the suppression pattern healthy adults display when they observed actions of *others* (see also Bernier, Dawson, Webb, & Murias, 2007; Raymaekers, Wiersema, & Roeyers, 2009). A subsequent study by Oberman et al. (2008), however, qualified this effect: when ASD patients watched intentional actions of familiar persons rather than of strangers, their μ-pattern was normalized. According to the authors, these results suggest that adequate social processing depends on the *relevance* or *salience* which our attentional system grants to social stimuli.

Some preliminary support for SRH also comes from studies with psychologically unaffected individuals. Kilner and Lemon (2013) tested whether, if the type of action is fixed, the perspective from which it is viewed can affect the MEG μ-suppression. Their idea was that watching an action from the front should capture attention to a higher degree (the action could directly affect you) than watching actions from the back (the action need not directly concern you), and that this difference in attentional relevance affects action processing. As predicted, the μ-suppression was stronger when observing actions from the front compared to when observing them from the back, suggesting that actions with different degrees of relevance are represented differently. Brown, Wiersema, Pourtois, and Brüne (2013) showed that the strength of the μ-suppression was modulated by the degree of reward associated with actions, suggesting that we devote a higher amount of attentional resources to actions that are more rewarding (cf. also Trilla Gros, Panasiti, & Chakrabarti, 2015).

These findings motivate the idea that the degree of relevance of the social stimuli we are confronted with is a key element for social processing. Now, evidence for SRH primarily stems from experiments that focus on the effects on social performance of attentional manipulations in ASD patients. However, although SRH's predictions about socio-pathological patient groups such as ASD are important and interesting, SRH is a general hypothesis about the mechanisms underlying social processing. SRH claims that, under normal conditions, social stimuli come with a high degree of behavioral, and thus attentional relevance. Since stimuli that usually display a high degree of biological and behavioral relevance should be processed efficiently in an automatic and bottom-up manner (Eastwood, Smilek, & Merikle, 2001; Egeth & Yantis, 1997; Geng & Mangun, 2009; Parkhurst, Law, & Niebur, 2002; Peck, Jangraw, Suzuki, Efem, & Gottlieb, 2009; Pratto & John, 1991; Summerfield & Egner, 2009; Treue, 2003; Wang, Cavanagh, & Green, 1994), a prediction of SRH is that normally, social stimuli capture our attention automatically and are thus processed in a bottom-up driven way. Consequently, the proper processing of such stimuli depends on that bottom-up automaticity. It should then generally be possible to boost social cognition performance by enhancing bottom-up attention to social stimuli. To test this prediction, we conducted an EEG experiment in which we examined whether boosting attentional bottom-up processing increases μ-suppression, taken as a signal for intentional action processing.

[1] We want to clarify that we focus on automatic processes triggered by bottom-up attention. This presupposes the well-accepted distinction between bottom-up and top-down attentional mechanisms, but does not imply that automatic processes triggered by bottom-up attention are independent from complex cognitive processes. Bottom-up attention might still be subject to cognitive penetration, which is the modification of our perceptual experience by higher-level cognition (Vetter & Newen, 2014). The important distinction we draw on in this paper is between automatic processes which are triggered only by bottom-up attention, and those non-automatic processes which also involve top-down attentional processes (e.g., higher-level control processes).