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Cognitive penetration of early vision in face perception

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ABSTRACT

Cognitive and affective penetration of perception refers to the influence that higher mental states such as beliefs and emotions have on perceptual systems. Psychological and neuroscientific studies appear to show that these states modulate the visual system at the visuomotor, attentional, and late levels of processing. However, empirical evidence showing that similar consequences occur in early stages of visual processing seems to be scarce. In this paper, I argue that psychological evidence does not seem to be either sufficient or necessary to argue in favour of or against the cognitive penetration of perception in either late or early vision. In order to do that we need to have recourse to brain imaging techniques. Thus, I introduce a neuroscientific study and argue that it seems to provide well-grounded evidence for the cognitive penetration of early vision in face perception. I also examine and reject alternative explanations to my conclusion.

1. Introduction

Cognitive and affective penetration of perception refers to the influence that higher mental states have on perceptual systems. This phenomenon is observed when beliefs, expectations, or feelings, moods, among other states, modulate perceptual processing (Churchland, 1979, 1989; Fodor, 1983, 1984, 1988, 2000; Fodor & Pylyshyn, 1981; Raftopoulos, 2001c, 2001a, 2001b, 2009, 2011, 2017). Specifically, this debate concerns the influence of top-down cognitive or affective signals on early stages of visual processing. Cognitive penetration of the early visual system would be observed if persistent illusions, such as Müller-Lyer or Ponzo illusions, are the result of neural reorganisation elicited by the constant influence of cognitive states, e.g., our knowledge of perspective and geometry, on early stages of visual processing (Churchland, 1988, p. 174; McCauley & Henrich, 2006). Affective penetration seems to occur when top-down affective states, such as fear or anger, influence early vision so that fearful or threatening objects are perceived more accurately (Gamond et al., 2011; Morel, Ponz, Mercier, Vuilleumier, & George, 2009; Morel, George, Foucher, Chammat, & Dubal, 2014; Soares & Esteves, 2013; Stolarova, Keil, & Moratti, 2006; Zhu & Luo, 2012).[1]

Cognitive and affective penetration of perception appears to influence the system's behaviour, its structural organisation, and the

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[1] In this introduction, I have described cognitive and affective penetration of perception with regard to early vision. However, it is worth noticing that the cognitive penetrability debate can also be interpreted with reference to the perceptual experience (Gatzia, 2017; Macpherson, 2012; Siegel, 2012, 2013b; Silins, 2016; Stokes, 2013). In this latter debate, the matter at issue is whether the content of the perceptual experience can be modulated by cognitive or affective mental states, rather than whether the locus of top-down penetrating influences is early vision, late vision, or the perceptual experience itself. In other words, the focus of interest is the phenomenal character of the perceptual experience: what is like to perceive an object (Macpherson, 2011b, p. 129, 2012, pp. 24–28; Siegel, 2012, p. 203; Teufel and Nanay, 2017, p. 18). These two debates — i.e., the penetration of early vision and the penetration of the perceptual experience by higher states — are often considered as independent from and complementary to each other (Fodor, 1983, pp. 73–74; Macpherson, 2012, p. 29; Pylyshyn, 1984, p. 174, 1999, p. 344; Raftopoulos, 2005, pp. 75–76, 2011, p. 8; Siegel, 2013b, p. 699, fn.4; Siegel and Silins, 2015, p. 804, fn. 55; Teufel and Nanay, 2017, p. 18). The focus of this article is the cognitive and affective penetration of the early visual system.

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processing of the stimuli (content of perception). Penetrating states can modify the system's behaviour by heightening the cortical representation of some stimuli and boosting visual processing (Miskovic & Keil, 2013; Oosterwijk, Lindquist, Adebayo, & Barrett, 2016). Emotions like fear seem to modulate the visual processing at very short latencies by sensitising the system to detect potential threat faster (Brendel, Hecht, DeLucia, & Gamer, 2014) and prepare the organism for defensive actions (e.g., flee or fight) (Weymar, Keil, & Hamm, 2014). Thus, compared to neutral or positive stimuli, fearful stimuli like facial expressions (Marchi & Newen, 2015; Morel et al., 2009; Soares & Esteves, 2013; Wang et al., 2012; Zhang, Liu, Wang, Ai, & Luo, 2017; Zhu & Luo, 2012) or threatening stimuli like angry faces (Zhang et al., 2017) or spiders (Brendel et al., 2014; Domínguez-Borràs, Rieger, Corradi-Dell'Acqua, Neveu, & Vuilleumier, 2017) can be detected faster and more accurately. Likewise, attentional mechanisms also seem to be modulated by emotions (Aue & Okon-Singer, 2015; Pourtois, Grandjean, Sander, & Vuilleumier, 2004; Soares & Esteves, 2013; Zhang et al., 2017), intentions (Land, 2006, 2009; Mole, 2015; Wu, 2013, 2014, 2017), or previous knowledge (Duclos, 2015).

As a consequence of the plastic condition of the brain, higher states appear to cause structural (architectural) changes (Gilbert, Li, & Piëch, 2009; Gilbert & Li, 2012; Pourtois, Rauss, Vuilleumier, & Schwartz, 2008). Top-down modulatory states triggered during a perceptual learning task might induce neural reorganisation (Byers & Serences, 2012; Cecchi, 2014; Gatzia & Brogaard, 2017; Hohwy, 2017; Li, Piëch, & Gilbert, 2004; Makino & Komiyama, 2015; Zhang, Li, Song, & Yu, 2015). For instance, the beliefs and intentions involved in an intensive training task might be responsible for subsequent long-lasting neural adaptation in the visual cortex (Byers & Serences, 2012; Cecchi, 2014; Rauss, Pourtois, Vuilleumier, & Schwartz, 2009; Rauss, Schwartz, & Pourtois, 2011).

Cognitive and affective penetrating states can also affect the processing of the stimuli and modulate the content of perception (Arstila, 2018; Borst & Kosslyn, 2010; Gatzia & Brogaard, 2017; Miskovic & Keil, 2013; Morel et al., 2014; Oosterwijk et al., 2016). Desires (Balcetis & Dunning, 2006, 2007), motivation or optimism (Witt & Proffitt, 2005), and hunger or thirst (Balcetis & Dunning, 2010) can bias the perception of distances and objects' sizes.

The cognitive and affective penetration of perception is of great importance for philosophy, psychology, neuroscience, and other fields like psychiatry, marketing, consumer behaviour, and finance.

From a philosophical perspective, cognitive and affective influences on perception represent an epistemic problem. Perceptual experiences are the foundation of our visual knowledge since it is on the basis of what we see that we are justified in believing one way or another (Engel, 2007; Lyons, 2011; Siegel, 2012, 2013b; Siegel & Silins, 2015). If the perceptual process is corrupted by our cognitive or affective background, we might not see the world as it is but as we want or expect it to be (Fodor, 1983, p. 68; Pylyshyn, 1980). Therefore, we might fail to know the world (Clark, 2016, 2011, 2015, 2016, 2012, 2017; Siegel, 2012).

The apparent encapsulation (isolation) of the visual system from cognitive and affective states appears to have behavioural advantages for the speed and the objectivity of perceptual integration (Fodor, 1983, p. 43; Pylyshyn, 1984, p. 155; Raftopoulos, 2001c, p. 188), and the reliability of the visual processing (Fodor, 1983, p. 68). In other words, perceptual modularity seems to make the world safe for knowledge (Lyons, 2011, p. 305). (See also Burnston & Cohen, 2015; Fodor, 1984, 1988, 2000; Pylyshyn, 1980, 1984, 1999, 2003; Raftopoulos, 2001a, 2009, 2017.) However, recent research shows that cognitive and affective influences on perception appear to be the norm of the brain. The subject's cognitive and affective background plays a fundamental role in the way we perceive objects, as it helps to interpret the environment in the most adequate manner (Churchland, 1979, 1989; Clark, 2013, 2014, 2015, 2016; Lyons, 2011; Marchi & Newen, 2015; Machery, 2015; Macpherson, 2012, 2015, 2017; Ogilvie & Carruthers, 2016; Teufel & Nanay, 2017).

A similar ongoing debate is observed in psychology. Theoretical approaches (Balcetis, 2016; Churchland, Ramachandran, & Sejnowski, 1994; Collins & Olson, 2014; Hohwy, 2013, 2017; Lupyan, 2012, 2015; Lupyan, Thompson-Schill, & Swingley, 2010; Newen & Vetter, 2017; Vetter & Newen, 2014) and empirical evidence seem to show that higher influences on visual processing have consequences for human behaviour. Penetrating higher states might harm social interaction if faces look angrier than they really are (Zhang et al., 2017), discourage actions if distances or heights look bigger than expected (Storbeck & Stefanucci, 2014; Stefanucci & Proffitt, 2009), alter the performance of a task if objects look different (den Daas, Häfner, & de Wit, 2013; Witt & Proffitt, 2005), affect business if beverages taste less palatable than they normally do (Harrar, Piqueras-Fiszman, & Spence, 2011; Piqueras-Fiszman & Spence, 2012; Wanab, Woods, Seoul, Butcher, & Spence, 2015), and the like. Still, some psychologists argue that there is no conclusive evidence for the cognitive and affective penetration of perception (Firestone & Scholl, 2014, 2015a, 2015b, 2016; Pylyshyn, 1999, 2003).

Finally, the debate extends to the field of neuroscience. A successful interaction with the surrounding world depends on the organism's ability to predict future events and plan behaviour. The brain is continuously storing and updating information about associations between objects, events, and their specific contexts. Rather than passively waiting to be activated by external inputs, the brain takes advantage of stored associations to generate predictions about the world it encounters. Predictions facilitate perception by helping to construct a coherent representation of the incoming inputs based on the stored information (Baars & Gage, 2010; Bar, 2004, 2007, 2009b, 2009a; Bar, Kassam, Ghuman, Boshyan, & Schmid, 2006; Friston, 2005, 2008; Gilbert & Sigman, 2007; Irwin & Thomas, 2008; Kveraga, Ghuman, & Bar, 2007; Panichello, Cheung, & Bar, 2013; Perlman, Hoffman, Tzelgov, Pothos, & Edwards, 2016).

Some predictive processes are achieved by affective and cognitive states that might strengthen visual processing efficiency, enhance synapses, elicit neural reorganisation, and the like (Brendel et al., 2014; Rauss et al., 2011; Weymar et al., 2014). These effects have important theoretical and empirical consequences for brain architecture (e.g., anatomy, plasticity) (Gilbert et al., 2009; Gilbert & Li, 2012; Qin & Yu, 2013), brain functioning (e.g., consciousness, perceptual learning, development) (Bar, 2009b, 2009a; Byers & Serences, 2012; Cheung & Bar, 2014; ÓCallaghan, Kveraga, Shine, Adams, & Bar, 2017; Panichello et al., 2013; Rauss et al., 2011; Rauss & Pourtois, 2013; Trapp & Bar, 2015), and explanatory models (e.g., predictive coding, ERP analysis) (Clark, 2013, 2016; Hohwy, 2013; Rauss, Pourtois, & Vuilleumier, 2012; Rauss & Pourtois, 2013; Spratling, 2016). For instance, empirical studies seem to