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Asymmetric switch-costs and ERPs reveal facial identity dominance over expression

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ABSTRACT

Previous studies on face processing have revealed an asymmetric overlap between identity and expression, as identity is processed irrespective of expression while expression processing partly depends on identity. To investigate whether this relative interaction is caused by dominance of identity over expression, participants performed familiarity and expression judgments during task switching. This paradigm reveals task-set dominance with a paradoxical asymmetric switch-cost (i.e., greater difference between switch and repeat trials when switching toward the dominant task). Event-related potentials (ERPs) were recorded to find the neural signature of the asymmetric cost. As expected, greater switch-cost was shown in the familiarity task with respect to response times, indicating its dominance over the expression task. Moreover, a left-sided ERP correlate of this effect was observed at the level of the frontal N2 component, interpreted as an index of modulations in endogenous executive control. Altogether, these results confirm the overlap between identity and expression during face processing and further indicate their relative dominance.

1. Introduction

Faces are one of the most salient stimuli for humans, as they convey information about identity, emotion, gender, age, social status, and so on. One intriguing question investigated for the last thirty years concerns interactions between facial dimensions, especially identity and emotional expression. In the traditional view of face processing, identity and expression involve independent and parallel visual systems (Bruce & Young, 1986), an assumption supported by neuropsychological (Tranel, Damasio, & Damasio, 1988), and behavioral (Campbell, Brooks, de Haan, & Roberts, 1996; Young, McWeeny, Hay, & Ellis, 1986) studies as well as neuroimaging (Sergent, MacDonald, & Zuck, 1994), and event-related potentials (ERP) (Bobes, Martin, Olivares, & Valdés-Sosa, 2000; Caharel, Courtay, Bernard, Lalonde, & Rebaï, 2005) recordings. However, several studies in the last decade indicate overlapping between the two dimensions in neurologic and psychiatric patients (Baudouin, Martin, Tiberghien, Verlut, & Franck, 2002; Gallegos & Tranel, 2005; Martin, Baudouin, Tiberghien, & Franck, 2005), as well as in healthy subjects (Bate, Haslam, & Hodgson, 2009; Baudouin, Gilibert, Sansone, & Tiberghien, 2000; Campbell & Burke, 2009; Dobel et al., 2008; Ellamil, Susskind, & Anderson, 2008; Fox, Oruç, & Barton, 2008, 2009; Fox, Young Moon, Iaria, & Barton, 2009; Ganel & Goshen-Gottstein, 2004; Ganel, Valyear, Goshen-Gottstein, & Goodale, 2005; Kaufmann & Schweinberger, 2004; Lander & Metcalfe, 2007; Leleu et al., 2010; Schweinberger & Soukup, 1998; Schweinberger, Burton, & Kelly, 1999; Vuilleumier, Armony, Driver, & Dolan, 2001; Wild-Wall, Dimigen, & Sommer, 2008). Relative interactions between the two processes are also proposed in a recent model of face perception based on principal component analysis (Calder & Young, 2005).

1.1. The nature of interactions between facial identity and expression

The term "relative" indicates different degrees of dependencies between identity and expression. The first probing illustration of a relative interaction between the two face dimensions was found by the seminal work of Schweinberger and Soukup (1998). Using the selective attention paradigm described by Garner (1976), they showed that subjects are able to attend selectively to identity regardless of the emotion expressed, whereas expression classifications are strongly influenced by irrelevant information on identity. Other studies have found the same kind of interaction with the Garner-type paradigm in healthy participants (Schweinberger et al., 1999) and schizophrenic patients (Baudouin et al., 2002; Martin et al., 2005). More recently, data on visual aftereffects show adaptation to expression partly depending on features important for identity, while representations of identity are independent of variations in expression (Campbell &

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Burke, 2009; Ellamil et al., 2008; Fox et al., 2008). In addition, fMRI studies provide evidence of functional overlap in the cortical network of face processing proposed by Haxby, Hoffman, and Gobbini (2000). Although the fusiform face area (FFA) and the superior temporal sulcus (STS) are associated respectively with identity and expression processing in the core system of this model, greater activation can be observed in the FFA when subjects attend to either identity or expression and in the STS when they only attend to expression (Fox et al., 2009; Ganel et al., 2005; Vuilleumier et al., 2001).

There are cases where expression influences identity processing, especially for familiar faces. Using the Garner-type paradigm, Ganel and Goshen-Gottstein (2004) observed greater interference for familiar than for unknown faces in both identity and expression judgments. Furthermore, there is a body of research that supports the idea of more accurate and/or faster recognition of familiar faces expressing happiness (Bate et al., 2009; Baudouin et al., 2000; Dobel et al., 2008; Gallegos & Tranel, 2005; Kaufmann & Schweinberger, 2004; Lander & Metcalfe, 2007; Wild-Wall et al., 2008), whereas some studies found reduced familiarity judgments for negative-expression faces (Bate et al., 2009; Dobel et al., 2008; Lander & Metcalfe, 2007; Leleu et al., 2010). These interactions may gradually appear as soon as learned faces become familiar and are stored in memory, probably due to their affective value. On the contrary, expression processing is always influenced by the identity of the face irrespective of its familiarity, suggesting that the expression analysis system necessarily takes into account individual identity due to an adaptive bias (e.g., Schweinberger & Soukup, 1998). The most compelling interpretation of all findings with familiar and unknown faces is that systems processing identity and expression are partially interconnected, in that facial identity serves as a reference from which expressions are more easily but not exclusively derived (Ellamil et al., 2008; Fox et al., 2008, 2009; Ganel & Goshen-Gottstein, 2004; Ganel et al., 2005; Kaufmann & Schweinberger, 2004). One can argue that the direction in which an interaction between two dimensions occurs depends on the relative speed with which each dimension is processed and/or on the relative dominance of each dimension for the cognitive system (for a discussion, see Garner, 1983).

1.2. Time course of facial identity and expression processing

Because of their fine temporal resolution, ERP studies have been designed to investigate the time course of face processing. Sensitivity to face configurations emerges as early as 80 ms after stimulus-onset with the P1 occipito-temporal component reflecting face detection (e.g., Herrmann, Ehlis, Ellgring, & Fallgatter, 2005). The P1 component is also an index of facial expression detection (e.g., Batty & Taylor, 2003). However, the first stage at which enough evidence is accumulated to identify an individual face is indexed by the N170 component appearing around 160 ms after stimulus-onset (for a review, see Rossion & Jacques, 2008; see also Caharel, d'Arripe, Ramon, Jacques, & Rossion, 2009; Jacques & Rossion, 2009 for more recent references). The discrimination between expressions can also be realized in the same time range, as indexed by an adaptation effect (i.e., reduction of the electrophysiological signal in response to stimulus repetition) on the N170 (e.g., Campanella, Quinet, Bruyer, Crommelinck, & Guerit, 2002). Thus, identity and expression may be processed during the same time course, as we found interactions between familiarity and expression appearing in the N170 time range for both familiarity and expression tasks (Leleu et al., 2010). Altogether, these results suggest that face dimensions are processed at the same speed. If so, one dimension may achieve dominance over the other (Garner, 1983). This intriguing question can be investigated with a paradigm that can reveal interactions and the relative dominance between two dimensions of the same object: task switching.

1.3. Asymmetric switch-cost to investigate dominance of facial identity

As in the Garner-type paradigm, task switching (i.e., task alternations allowing a switch-cost—longer response times (RTs) during switch compared to repeat trials, see Kiesel et al., 2010; Vandierendonck, Liefooghe, & Verbruggen, 2010 for recent reviews) can highlight interactions between two dimensions by manipulating selective attention at several levels of processing. Perceptual interactions can first be observed depending on the nature of the stimuli and their trial-to-trial relations. We used task switching with bivalent faces (i.e., same stimuli used in both tasks) and competitor priming (i.e., the irrelevant dimension in a switch trial being the same as the relevant one in the previous repeat trial) and showed interactions in early perceptual stages of visual processing as soon as the N170 component (Leleu et al., 2010), whereas no interaction occurred in other ERP studies where subjects performed the two tasks in separate sessions with randomly counterbalanced stimuli (e.g., Caharel et al., 2005). Secondly, executive interactions can be observed in task switching with response-based interference. When the same response-set is used to perform the two tasks (bivalent response-set), each motor response has different meanings depending on the task, allowing for congruency effects in executive control (e.g., Brass et al., 2003). Thirdly, interactions can be highlighted to a larger extent at the level of task sets, also called stimulus–response (S–R) mappings, and defined as the organization of mental representations and cognitive processes that enable to act in accordance with task requirements. Indeed, when participants perform two tasks alternatively, an active task-set reconfiguration occurs and is partly responsible for the switch-cost. It is interesting to note that when tasks differ in dominance, an interaction in the reconfiguration of task sets is indicated by a paradoxical asymmetric switch-cost (Allport & Wylie, 2000; Allport, Styles, & Hsieh, 1994; Barton, Greenzang, Hefter, Edelman, & Manoach, 2006; Meuter & Allport, 1999; Philipp, Gade, & Koch, 2007; Yeung & Monsell, 2003). This well-known effect was first reported by Allport et al. (1994) with Stroop tasks (Stroop, 1935), as costs were larger when switching toward the dominant and stronger color-word reading task than the non-dominant and weaker ink-color naming task, replicated since then (Allport & Wylie, 2000; Yeung & Monsell, 2003), but also occurring when switching between native and learned languages (Meuter & Allport, 1999; Philipp et al., 2007) or between saccades and antisaccades (e.g., Barton et al., 2006).

Hence, to investigate whether interactions between identity and expression are due to differences in dominance, we designed a task-switching procedure whereby subjects performed familiarity and expression judgments. We sought to find a greater switch-cost in the familiarity than in the expression task. Because we did not find an asymmetric switch-cost in our previous task-switching study (Leleu et al., 2010), stimuli were randomly counterbalanced in the present experiment, expecting to enhance interaction in task sets. Indeed, because subjects were able to predict the irrelevant dimension in a switch trial, competitor priming in the previous research may have attenuated interaction in task sets and intensified interactions in perceptual representations of faces as we found in early visual ERP components. To clarify when interactions in reconfiguration of task sets start from along the processing stream, ERPs were also recorded. The aim was to discover correlates of asymmetric switch-costs by analyzing parieto-central P3 and fronto-lateral N2 components often investigated in the task-switching literature (e.g., Karayanidis, Coltheart, Michie, & Murphy, 2003; Poulsen, Luu, Davey, & Tucker, 2005), related to post-perceptual and executive processes associated with reconfiguration of task sets. We also analyzed occipito-temporal P1 and N170 components to investigate switch-costs at perceptual stages.