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Altered saccadic targets when processing facial expressions under different attentional and stimulus conditions

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ABSTRACT

Depending on a subject's attentional bias, robust changes in emotional perception occur when facial blends (different emotions expressed on upper/lower face) are presented tachistoscopically. If no instructions are given, subjects overwhelmingly identify the lower facial expression when blends are presented to either visual field. If asked to attend to the upper face, subjects overwhelmingly identify the upper facial expression in the left visual field but remain slightly biased to the lower facial expression in the right visual field. The current investigation sought to determine whether differences in initial saccadic targets could help explain the perceptual biases described above. Ten subjects were presented with full and blend facial expressions under different attentional conditions. No saccadic differences were found for left versus right visual field presentations or for full facial versus blend stimuli. When asked to identify the presented emotion, saccades were directed to the lower face. When asked to attend to the upper face, saccades were directed to the upper face. When asked to attend to the upper face and try to identify the emotion, saccades were directed to the upper face but to a lesser degree. Thus, saccadic behavior supports the concept that there are cognitive-attentional pre-attunements when subjects visually process facial expressions. However, these pre-attunements do not fully explain the perceptual superiority of the left visual field for identifying the upper facial expression when facial blends are presented tachistoscopically. Hence other perceptual factors must be in play, such as the phenomenon of virtual scanning.

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1. Introduction

Analysis of facial expressions, as a means to infer hemispheric lateralization of emotional processing, has focused traditionally on differences in the degree of expressiveness between the right and left hemiface (Borod & Caron, 1980; Borod, Kent, Koff, Martin, & Alpert, 1988; Borod, Koff, & White, 1983; Campbell, 1978; Ekman, 1980; Ekman, Hager, & Friesen, 1981; Kowner, 1995; Rinn, 1984; Sackeim & Gur, 1978; Sackeim et al., 1978; Thompson, 1985). A meta-analysis of sixteen published studies (Skinner & Mullen, 1991) concluded that the left hemiface was more expressive than the right hemiface for posed but not spontaneous emotions and for pleasant but not negative emotions. However, the average r^2-value across the 16 studies was 0.036, explaining approximately 3.6% of the data variance, thus indicating a rather weak behavioral effect for inferring hemispheric modulation of emotional processing based on right-left asymmetry of facial expressions (Kowner, 1995; Ross, Prodan, & Monnot, 2007a; Ross, Reddy, Nair, Mikawa, & Prodan, 2007b; Skinner & Mullen, 1991; Thompson, 1985; Ross and Pulusu, 2013).

In contrast, social psychologists have suggested that the modulation of facial expressions is organized predominantly across the upper-lower hemiface because of the phenomena of facial blends of emotions (Nummenmaa, 1964; Ekman & Friesen, 1975, 1982; Ekman, Davidson, & Friesen, 1990; Ekman, Friesen, & O'Sullivan, 1988; Ekman, 1992; Larsen, McGraw, & Cacioppo, 2001; see far right panel in Fig. 1). Facial blends occur when two different emotions appear simultaneously on the upper and lower face.

1.1. Facial blends of emotion

Facial blends are related to social-types of emotions and the development of 'display rules' in young children that eventually provide adults with the cognitive ability to control their facial expressions for social and manipulative purposes. Primary emotions, such as anger, fear, surprise, disgust and joy are related to self-preservation and fight-flight behaviors (Buck, 1988; Izard, 1977) and their associated facial expressions are thought to be innate because they are recognized universally across different

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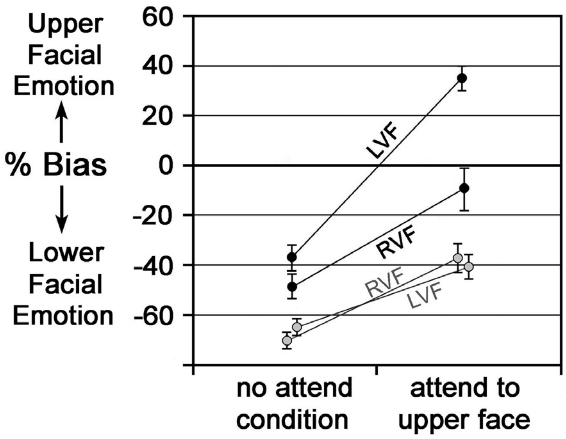

Fig. 1. Perceptual results when young adult subjects (20–61 years of age; black data points from Prodan et al. (2001)) and elderly adult subjects (65–78 years of age; light gray data points from Prodan et al. (2007)) are tachistoscopically presented with facial blends of emotion to their right and left visual fields (RVF, LVF) under no attentional instructions compared with instructions to attend to the upper face. The statistical relations were very robust with most effect sizes explaining more than 50% of the data variance (Ross et al., 2007a). Variance hats represent SEMs.

cultures (Ekman & Friesen, 1975; Panksepp, 1998). Social emotions, such as envy, jealousy, scorn, arrogance, pride and embarrassment, are acquired during early development through social interactions as part of the biological drive for attachment and to gain admiration, approval, acceptance or affection from others (Buck, 1988). Social emotions are not associated with specific, hard-wired, types of facial expressions but rather with the phenomenon of display rules. As part of the socialization process, display rules are acquired early in childhood and enable individuals to eventually learn to cognitively control their primary emotional facial displays to make them socially acceptable (Ekman & Friesen, 1969; Lewis & Michalson, 1983; Malatesta & Kalnok, 1984). The most common ploy is the "false" lower face smile (Ekman, Friesen, & O'Sullivan, 1988; Ekman et al., 1990; Ekman & Friesen, 1975, 1982) to enable approach behaviors. As humans become cognitively adept, they may also employ intensification (enhancing a felt emotional display), minimization (dampening a felt emotional display), neutralization (not displaying a facial emotion when experiencing a felt emotion), simulation (displaying a facial emotion that is not associated with a felt emotion), dissimulation (displaying a facial emotion that is different from a felt emotion) and qualification (facial blends of emotion) (Ekman, 2003; Ekman & Friesen, 1982). Buck and Duffy (1980) studying patients with focal ischemic strokes have shown unequivocally that display rules are impaired by left but not right hemisphere lesions, consistent with the emotion-type hypothesis of lateralization that posits primary emotions and related displays are modulated predominantly by the right hemisphere whereas social emotions and related display rules are modulated predominantly by the left hemisphere (Ross, Homan, & Buck, 1994; Ross et al., 2007a).

Based on the above observations by social psychologists, our laboratory has completed a series of research projects to explore the concept that the perception and expression of facial emotions in humans is organized primarily across the upper-lower hemiface and only secondarily across the right-left hemiface (Prodan, Orbelo, & Ross, 2007; Prodan, Orbelo, Testa, & Ross, 2001; Ross et al., 2007a, 2016; Ross, Shayya, Champlain, Monnot, & Prodan, 2013). Using tachistoscopic presentations of facial blends of emotion to the right and left visual fields (**RVF, LVF**), Prodan et al. (2001) demonstrated that the LVF/right hemisphere preferentially identified the upper facial emotion when young adult subjects (20–61 years of age) were asked to attend to the upper face. In contrast, lower facial emotions were processed preferentially by both visual fields when no attentional instructions were given (Fig. 1, black data points). The results were very robust explaining up to 64% of the data variance (Prodan et al., 2001; Ross et al., 2007a). In a follow up study of elderly adults (65–78 years of age), the ability to identify the upper facial emotion, even when asked to attend to the upper face, is markedly muted (see Fig. 1, gray data points; Prodan et al., 2007; Ross et al., 2007a) compared to young adults, especially for the LVF. The results were very robust with a linear multiple-regression analysis of the combined data from the young and elderly adults identifying three regressors that modeled age [$F_{(3,52)} = 54.8$, $P < 0.00001$, R^2-adjusted = 0.75], explaining approximately 75% of the data variance. These findings were interpreted as being consistent with the right-hemisphere cognitive aging hypothesis (Botwinik, 1977; Hochnadel & Kaplan, 1984; Prodan et al., 2007).

1.2. Saccadic eye movements as a means to explore perceptual biases

Saccades can be broadly classified as being either exogenous or endogenous with specific cortical regions modulating different aspects of saccadic behavior (Amiez & Petrides, 2009; Bindemann, Scheepers, & Burton, 2009; Findlay, 2009; Gaymard et al., 1998; Henderson, 2003; Johnston & Everling, 2008; Krauzlis, 2005; McDowell, Dyckman, Austin, & Clementz, 2008; Müri & Nyffeler, 2008; Paus, 1996; Paus, Petrides, Evans, & Meyer, 1993; Schiller & Tehovnik, 2005). Exogenous or reflexive saccades are generated as a reaction to the sudden appearance of an object, animal or person in the visual field. They are thought to be modulated predominantly by lateral geniculate inputs to visual cortex and the parietal eye fields with outputs to the brainstem ocular-motor system via the superior colliculi. Endogenous or goal-directed (volitional) saccades are generated when individuals actively explore their visual environment. They are thought to be modulated predominantly through temporal, occipital and parietal inputs to either the lateral frontal eye fields or medial frontal regions that include the supplementary and cingulate eye fields with direct outputs to the brainstem ocular-motor system that bypass the superior colliculi. Thus, endogenous as compared to exogenous (reflexive) saccades are more likely to be conditioned by cognitive, attentional or perceptual imperatives (Findlay, 2009). In addition, some saccades may be induced by both exogenous and endogenous initiators. When this occurs, the respective motor outputs are thought to undergo competitive integration by the superior colliculus prior to saccadic initiation (Godijn & Theeuwes, 2002; Meeter, Van der Stigchel, & Theeuwes, 2010; Trappenberg, Dorris, Munoz, & Klein, 2001).

In our previous studies (Prodan et al., 2001, 2007), the facial expression stimuli were presented tachistoscopically for ~150 ms, i.e. enough time to initiate a saccadic reaction but not enough time for a saccadic eye movement to be completed. This was done to ensure that the image would be presented exclusively to the RVF/left hemisphere or LVF/right hemisphere for perceptual processing. However, the studies did not evaluate saccadic behavior as a means to identify if there might be cognitive pre-attunements associated with the perceptual biases. For example, when subjects are given no attentional instructions, is their perceptual bias to the lower hemiface associated with the initial saccade being directed to the lower face? In contrast, when subjects are given instructions to attend to the upper face, is their perceptual bias to the upper hemiface for LVF presentations associated with the initial saccade being directed to the upper face, whereas for RVF presentations did their initial saccade remain directed to the lower face?