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Decline or improvement? Age-related differences in facial expression recognition

Atsunobu Suzuki [a,*], Takahiro Hoshino [a], Kazuo Shigemasu [a], Mitsuru Kawamura [b]

[a] *Department of Cognitive and Behavioral Science, Graduate School of Arts and Sciences, The University of Tokyo, 3-8-1 Komaba, Meguro-ku, Tokyo 153-8902, Japan*
[b] *Department of Neurology, Showa University School of Medicine, 1-5-8 Hatanodai, Shinagawa-ku, Tokyo 142-8666, Japan*

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Abstract

We examined age-related differences in facial expression recognition in association with potentially interfering variables such as general cognitive ability (verbal and visuospatial abilities), face recognition ability, and the experiences of positive and negative emotions. Participants comprised 34 older (aged 62–81 years) and 34 younger (aged 18–25 years) healthy Japanese adults. The results showed not only age-related decline in sadness recognition but also age-related improvement in disgust recognition. Among other variables, visuospatial ability was moderately related to facial expression recognition in general, and the experience of negative emotions was related to sadness recognition. Consequently, age-related decline in sadness recognition was statistically explained by age-related decrease in the experience of negative emotions. On the other hand, age-related improvement in disgust recognition was not explained by the interfering variables, and it reflected a higher tendency in the younger participants to mistake disgust for anger. Possible mechanisms are discussed in terms of neurobiological and socio-environmental factors.

Keywords: Aging; Facial expression recognition; Disgust; Anger

Affective aging has attracted attention among researchers because of its unique life-span trajectory that is contrasted with cognitive aging. Despite a predominant view of age-related declines in cognitive functions (Hedden and Gabrieli, 2004), the socio-emotional selectivity theory proposed by Carstensen et al. (1999) argues that at least some aspects of emotional functions *improve* with advancing age. Specifically, the theory asserts that emotional experiences in older adults are optimally regulated in terms of the relative increase in positive emotions against negative emotions (Mather and Carstensen, 2005). Consistently with the theory, earlier studies examined age-related differences in daily emotional experiences using self-report questionnaires and found a decrease in negative emotions as well as maintenance of or increase in positive emotions (Carstensen and Charles, 1998; Mroczek, 2001). In addition, older adults reported better emotional control than their younger counterparts (Gross et al., 1997). Recent experimental studies also support this view: they show that older adults' attentional (Mather and Carstensen, 2003; Rosler et al., 2005) and memory (Charles et al., 2003) biases mask negative emotion elicitors (but see also Comblain et al., 2004; Kensinger et al., 2002 for contradictory findings on the memory bias).

However, the optimistic view on affective aging has recently been challenged by the research focusing on the other fundamental aspect of emotional functions, that is, emotion recognition. Human competency to infer and recognize others' emotional states – mostly from non-verbal cues – underlies success in interpersonal communication, and it is suggested that this competency involves age-related decline. Among others, facial expression recognition is the most thoroughly studied area in emotion recognition, of which neural and cognitive mechanisms are well documented (Adolphs, 2002; Calder et al., 2001); therefore, age-related differences in facial expression recognition have been of great interest.

In particular, the recognition of facial expressions of *basic emotions* (happiness, surprise, fear, anger, disgust, and sadness; Ekman, 1994; Russell, 1994) has been examined in detail

* Corresponding author. Tel.: +81 3 5454 6896; fax: +81 3 5454 6979.
E-mail address: suzuki@bayes.c.u-tokyo.ac.jp (A. Suzuki).

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(Calder et al., 2003; MacPherson et al., 2002; McDowell et al., 1994; Moreno et al., 1993; Phillips and Allen, 2004; Phillips et al., 2002; Sullivan and Ruffman, 2004). There are cross-nationally standardized photograph sets for such facial expressions (e.g., Ekman and Friesen, 1976; Matsumoto and Ekman, 1988), ensuring the comparability of different experiments by different researchers. Overall, the earlier studies indicated age-related declines in recognizing facial expressions of specific basic emotions; age-related declines in anger and/or sadness recognition are the most prevailing observations (Calder et al., 2003; MacPherson et al., 2002; McDowell et al., 1994; Moreno et al., 1993; Phillips and Allen, 2004; Phillips et al., 2002; Sullivan and Ruffman, 2004). This is followed by age-related decline in fear recognition (Calder et al., 2003; McDowell et al., 1994; Sullivan and Ruffman, 2004). Interestingly, not only age-related decline (Sullivan and Ruffman, 2004) but also age-related improvement (Calder et al., 2003) was observed in the recognition of facial expressions of disgust, although the authors interpreted the results as preservation instead of improvement.

The above-mentioned emotion-specific effects of aging have often been attributed to age-related structural and functional changes in the neural substrates that are hypothesized to play an important role in the recognition of specific basic emotions. At present, the involvement of dissociable neural substrates in the recognition of facial expressions of fear and disgust is particularly emphasized (Calder et al., 2001). Since Adolphs et al. (1994) demonstrated a disproportionate impairment of the recognition of fear in a patient with selective amygdala damage, a number of neurological (Broks et al., 1998; Calder et al., 1996; Sato et al., 2002) and functional imaging studies (Morris et al., 1996; Whalen et al., 1998; Yoshimura et al., 2005) have replicated the link between the amygdala and fear recognition. Damage to the amygdala also compromises the recognition of other emotions such as anger and sadness to a certain extent (Adolphs and Tranel, 2004; Fine and Blair, 2000); however, impairment of fear recognition is the most consistent and disproportionately severe one (Adolphs et al., 1999).

A disproportionate impairment of disgust recognition was first reported in patients with Huntington's disease (Sprengelmeyer et al., 1996, 1997), a hereditary neurodegenerative disorder associated with pathological changes in the basal ganglia and possibly in the insula (Hennenlotter et al., 2004; Thieben et al., 2002). The proposed contributions of the two neural substrates to disgust recognition are also confirmed in functional imaging research (Phillips et al., 1997; Sprengelmeyer et al., 1998) and in a single-case report (Calder et al., 2000).

Currently, less evidence is available with respect to the recognition of the other emotions, but a meta-analysis of functional imaging research (Murphy et al., 2003) highlights the activation of the orbitofrontal cortex in response to facial expressions of anger.

Considering the involvement of the amygdala in fear recognition, and to a certain extent in anger and sadness recognition, the aging of the amygdala can explain age-related decline in recognizing facial expressions of fear (Calder et al., 2003), anger (Sullivan and Ruffman, 2004), and sadness (MacPherson et al., 2002). Indeed, a part of the medial temporal lobe structures, including the amygdala, is suspected to be mildly affected with advancing age (for a review, Raz, 2000). In line with the structural changes, age-related decrease in the amygdala activation in response to emotional stimuli (Gunning-Dixon et al., 2003; Iidaka et al., 2002), particularly to negative ones (Mather et al., 2004), is demonstrated.

A limitation of the amygdala aging hypothesis is that it may predict the most severe age-related decline in fear recognition (Adolphs et al., 1999; Calder et al., 2003), which does not appear to be the case; the age-related decline is reported most consistently in the recognition of anger and sadness. Thus, Sullivan and Ruffman (2004) suggest that the aging of the orbitofrontal cortex may underlie age-related decline in the recognition of anger. The effects of aging on the orbitofrontal cortex are indeed demonstrated by both structural (Convit et al., 2001; Raz et al., 1997; Tisserand et al., 2002) and functional (Lamar et al., 2004) examination. On the other hand, for sadness recognition, no dedicated neural substrates are currently indicated (Murphy et al., 2003) except the amygdala (Fine and Blair, 2000).

With regard to the preserved recognition of facial expressions of disgust, Calder et al. (2003) speculates that it may reflect the relative insensitivity of the globus pallidus to aging. Among other nuclei constituting the basal ganglia, it is suggested that the globus pallidus is activated most consistently in response to facial expressions of disgust (Murphy et al., 2003). However, a recent longitudinal study by Raz et al. (2003) showed that age-related shrinkage was indeed evident in the whole basal ganglia, although the shrinkage was milder in the globus pallidus than in the other nuclei (caudate and putamen). In addition, Good et al. (2001) reported age-related reduction in the gray matter volume of the insula. Thus, it appears that the neural substrates involved in disgust recognition may not be very insensitive to aging and that some other factors may underlie the preserved recognition of disgust in older adults.

As such, it has been explained that age-related differences in recognizing facial expressions of specific emotions may reflect some specific neurobiological factors. However, before identifying the emotion-specific factors, it is necessary to carefully examine the possibility that the observed emotion-specificity may stem in part from non-emotional factors. It is well known that the difficulty levels involved in recognizing facial expressions substantially differ across emotions. For example, fear is the most difficult emotion to recognize, and negative emotions as a whole are more difficult to recognize as compared with happiness and surprise (Biehl et al., 1997; Russell, 1994). Owing to the differential difficulty levels across emotions, general cognitive and visual disturbances can disproportionately impair the recognition of facial expressions of fear (Rapcsak et al., 2000) and negative emotions (Johnston et al., 2003). Since age-related decline in facial expression recognition is reported mainly in negative emotions, it is likely that the decline may be underlain at least in part by age-related cognitive and visual disturbances.

First, the effects of aging on general cognitive ability are well documented, and specifically, age-related decline in