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Research report

Age-related differences in brain activity during implicit and explicit processing of fearful facial expressions

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ABSTRACT

Age-related differences in neural correlates underlying implicit and explicit emotion processing are unclear. Within the framework of the Frontoamygdalar Age-related Differences in Emotion model (St Jacques et al., 2009), our objectives were to examine the behavioral and neural modifications that occur with age for both processes. During explicit and implicit processing of fearful faces, we expected to observe less amygdala activity in older adults (OA) than in younger adults (YA), associated with poorer recognition performance in the explicit task, and more frontal activity during implicit processing, suggesting compensation. At a behavioral level, explicit recognition of fearful faces was impaired in OA compared with YA. We did not observe any cerebral differences between OA and YA during the implicit task, whereas in the explicit task, OA recruited more frontal, parietal, temporal, occipital, and cingulate areas. Our findings suggest that automatic processing of emotion may be preserved during aging, whereas deliberate processing is impaired. Additional neural recruitment in OA did not appear to compensate for their behavioral deficits.

1. Introduction

Difficulties in processing emotional facial expressions (EFE) have been frequently reported in healthy older adults (OA, typically adults 60 years and older) when they have to perform an explicit recognition task. In these tasks, the participants are asked to label or name the emotion they feel or perceive when viewing a stimulus: emotion processing is then deliberate and conscious. The main findings suggest an impairment in the recognition of facial expressions of fear, anger, and sadness in OA compared with younger adults (YA, typically between 20 and 40 years old; Calder et al., 2003; Ekman and Friesen, 1976; Isaacowitz et al., 2007; Keightley et al., 2006; MacPherson et al., 2002, 2006; Phillips et al., 2002; Sullivan and Ruffman, 2004; Sullivan et al., 2007; Suzuki et al., 2007).

In these explicit tasks, the attention of the participant is focused on the emotional content of the stimuli. However, processing of valenced stimuli can be accomplished without consciousness of the emotions being displayed, through implicit processes that imply features of automaticity (Houwer and Moors, 2012). In implicit tasks, emotional content is either presented too fast to be consciously processed (i.e., subliminal protocols) or is irrelevant for the task and does not need to be processed: the participants have to focus on aspects of the stimulus other than the emotion to correctly perform the task (e.g., gender judgment task, color judgment task). However, there is evidence that emotions are processed in these tasks anyway. For example, increased physiological responses have been observed for emotional stimuli compared with neutral stimuli (Dimberg et al., 2000; Williams et al., 2004). Explicit and implicit tasks may call in different processes, and this reflects on OA performance: in contrast with the results observed in explicit tasks, the processing of all emotions seems to be preserved in OA when emotional abilities are assessed with implicit tasks (Garcia-Rodriguez et al., 2009; LaBar et al., 2005).

A key difference between the two types of protocols is probably the differential involvement of automatic and deliberate emotion processing. As discussed by Moors and De Houwer (2006), one may expect that automatic emotional processing is initiated in every situation involving an emotional cue regardless of the will of the individual. In other words, explicit emotion recognition tasks should include both controlled and automatic processing, as the latter would be automatically activated when an individual is confronted with an emotion, before it is perceived consciously. This indirectly suggests that the results observed for OA could reflect preserved automatic processing in both implicit and explicit tasks, but impairment of the additional processes concerning emotion recognition in explicit tasks. This hypothesis has been

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investigated by neuroimaging studies that assess brain processing of emotional information even when tasks do not provide a behavioral index of this processing (as in implicit tasks).

Previous studies report that when participants have to explicitly recognize EFE, OA present more activity in the middle and inferior frontal cortex than do YA (Gunning-Dixon et al., 2003; Keightley et al., 2007; Tessitore et al., 2005). In parallel, brain activity in OA is reduced in the dorsal anterior cingulate (Keightley et al., 2007), the right amygdala (Gunning-Dixon et al., 2003; Tessitore et al., 2005), and the bilateral posterior fusiform (Tessitore et al., 2005), compared with that in YA. OA had difficulties to recognize negative EFE in two of these studies (Gunning-Dixon et al., 2003; Keightley et al., 2007), but one study reported similar recognition performances between the two age groups (Tessitore et al., 2005). Therefore, it is unclear if the age-related differences observed in cerebral activity helped the OA to enhance their performance or not, when required to discriminate EFE. Furthermore, these differences involved cortical areas that sustain face recognition (fusiform gyrus; Haxby et al., 2000; Pourtois et al., 2010), as well as subcortical parts of the limbic system (amygdala) associated with automatic processing of emotion (Adolphs et al., 1999; Critchley et al., 2000). The only study comparing cerebral activity between OA and YA during implicit processing of EFE showed reduced limbic activity in the left amygdala and the right parahippocampal gyrus in OA, compared with that in YA (Iidaka et al., 2002). There were no differences in performance between age groups while implicitly processing EFE (gender judgment task). Taken as a whole, these observations suggest that, compared with YA, OA rely more on frontal cortices during explicit processing of EFE, although they recruit fewer limbic structures (e.g., amygdala, hippocampus) during both explicit and implicit processing.

Several issues need to be clarified in order to associate brain activity with automatic versus controlled processing. In particular, it is difficult to draw conclusions about the nature and specificity of functional modifications between age groups, as a direct comparison between an implicit and an explicit condition is lacking. One of the previous studies included an implicit (age decision) and an explicit (emotion discrimination) task within the same protocol; however, the analyses of cerebral activity focused on the age-related differences for the explicit condition only (Gunning-Dixon et al., 2003). Most studies also compiled brain activity from a recognition task performed on several impaired or preserved emotions in OA (Iidaka et al., 2002; Gunning-Dixon et al., 2003; Tessitore et al., 2005). Thus, it is difficult to conclude on the impact of the cerebral differences in OA compared to YA in the processing of specific emotions: could these functional changes underlie a better or worse recognition of which emotions? Although all studies included a measure of performance, none of them used it as an indicator of correct trials to analyze fMRI data. The participants of one study even performed the behavioral task outside of the scanner (Keightley et al., 2007), therefore there is no evidence that participants correctly performed the task while being scanned.

The general goal of our study was to assess age-related changes in brain activity with an experimental design that combined an explicit and an implicit task, making the comparison of the cerebral activations in these two conditions more reliable. To clarify the association between decreased and increased brain activity and the quality of emotion processing in aging, we focused on an emotion that OA have difficulties in recognizing. We selected EFE of fear for two reasons: (i) there is evidence that recognition of fearful faces is impaired with increasing age, and (ii) the processing of fearful faces has been repeatedly associated with amygdala activity (see Vytal and Hamann (2010)), a structure that seems to be affected by aging. The specific aim of this study was to investigate the compensatory hypothesis for EFE recognition in OA. The greater reliance of OA on frontal areas may indeed appear surprising, as these structures are particularly affected by aging (Raz, 2000). This reliance is, however, in accordance with the Frontoamygdalar Age-related Differences in Emotion (FADE) model (St Jacques et al., 2009). The FADE model assumes that OA recruit less of the amygdala and more of the frontal areas during emotional perception than do YA. Increases in the frontal activity of OA could reflect a compensatory mechanism or emotional regulation, or both, as emotional regulation can be seen as a form of compensation (St Jacques et al., 2010). Within the framework of the FADE model, we made the following predictions. We expected fewer areas to be activated in OA than in YA during the explicit task (including limbic areas such as the amygdala), contributing to poor recognition performance of fearful EFE. Amygdalar-dependent stimuli such as fearful faces are particularly relevant in assessing FADE predictions. In line with the assumption that both the implicit and the explicit tasks involve automatic processing, this decrease in amygdala activity should also occur in OA during implicit processing of fearful faces. As behavioral studies have suggested that the implicit processing of fearful expressions is preserved with aging, we predicted that more frontal structures would be activated in OA than in YA during implicit processing and thus play a compensatory role.

2. Results

Data from 17 OA and 17 YA were analyzed. The experiment consisted of two fMRI sessions one after the other, including an implicit and an explicit task. Both tasks required participants to give a GO/NOGO response, and their answers were recorded. In the implicit task, participants were instructed to attend to and judge the gender of fearful and neutral faces by pressing the response button when they saw a woman's face (or a man's face for half of the participants). In the explicit task, participants were instructed to attend to and judge the emotional expression of faces by pressing the button when they saw a fearful expression. We compared the groups (OA, YA) on the mean number of correct responses for the two emotion conditions (fear, neutral) and the two experimental conditions (implicit, explicit). We analyzed the functional data by taking into account only the correct trials for each participant.

2.1. Behavioral results

YA made significantly more correct responses ($M=113.45$, $SD=18.34$) than did OA ($M=94.65$, $SD=25.50$), regardless of the type of task and emotion, $F(1,31)=26.14$, $p<.05$, $\eta_p^2=.46$. We also found a main effect of task: participants overall made more correct responses in the implicit ($M=105.76$, $SD=14.14$) than in the explicit condition ($M=102.12$, $SD=30.87$), $F(1,31)=4.21$, $p<.05$, $\eta_p^2=.12$. We observed a main effect of emotion: participants made more correct responses when the face presented was neutral ($M=115.43$, $SD=16.09$) than when it was fearful ($M=92.39$, $SD=25.35$), regardless of the type of task and age group, $F(1,31)=90.04$, $p<.05$, $\eta_p^2=.74$. No interaction was observed between age groups and type of task ($F(1,31)=.20$, $p=.65$), or between emotion and group ($F(1,31)=3.80$, $p=.06$).

Interaction was observed between task and emotion ($F(1,31)=73.30$, $p<.05$, $\eta_p^2=.70$). Planned comparisons revealed that there were no significant differences in the number of correct responses between fearful and neutral faces in the implicit task ($F(1,31)=2.51$, $p=.12$). However, in the explicit task, participants overall made more correct answers for neutral faces ($M=124.24$, $SD=12.15$) than for fearful faces ($M=80$, $SD=27.91$), $F(1,31)=83.44$, $p<.05$, $\eta_p^2=.73$.