

# Aging Minds and Twisting Attitudes: An fMRI Investigation of Age Differences in Inhibiting Prejudice

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Cognitive capacity is believed to decline with age, but it is not known whether this decline extends to tasks involving social cognition. In the current study, social neuroscience methodologies were used to examine the effects of age-related cognitive decline on older adults' abilities to engage regulatory mechanisms (which are typically impaired by normal aging) to inhibit negative reactions to stigmatized individuals. Older and young adults were presented with images of stigmatized individuals (e.g., individuals with amputations, substance abusers) and of normal controls while they underwent functional magnetic resonance imaging. All participants were also given a battery of tests to assess their executive function capacity. Young adults showed more activity in areas associated with empathy (i.e., medial prefrontal cortex) than did older adults when viewing stigmatized faces. By contrast, older adults with relatively preserved levels of executive function had heightened activity in areas previously implicated in emotion regulation (i.e., lateral prefrontal cortex) as compared to other groups. These results suggest that although cognitive decline may interfere with older adults' attitudes toward stigmatized individuals, older adults with relatively preserved cognitive function may utilize different strategies to compensate for these deficits.

*Keywords:* aging, fMRI, stigma, executive function, social neuroscience

Extensive aging research has demonstrated that normal aging impairs cognition, with particular declines in memory (for a review, see Moscovitch & Winocur, 1995; Rajah & D'Esposito, 2005; Rapp & Heindel, 1994) and in executive function (Anderson & Craik, 2000; Moscovitch & Winocur, 1995), defined as higher level cognitive processes that facilitate planning, abstract reasoning, and inhibition. Emerging neuroimaging research has focused on identifying the mechanisms underlying this age-related cognitive decline. Such research has demonstrated that older adults have more widespread neural activity than do young adults when performing executive function tasks (Cabeza, Anderson, Locantore, &

McIntosh, 2002; Cabeza et al., 2004; Park & Reuter-Lorenz, 2009; Stern et al., 2008). These results suggest that older adults may compensate for cognitive systems that do not work efficiently (due to aging) by recruiting more neural activity (Cabeza, 2002; Morcom, Li, & Rugg, 2007; Rypma, Eldreth, & Rebbelchi, 2007; Zarahn, Rakitin, Abela, Flynn, & Stern, 2007).

Together, the results from the behavioral and neuroimaging aging literature have provided extensive insight into the effects of aging on cognition. However, the neuroimaging research has primarily focused on discrete domains of cognition (e.g., working memory, decision making) and has overlooked the effects of aging on other domains, such as social cognition, that rely on similar cognitive systems (Adolphs, 2003). Indeed, extensive behavioral research on social cognition and aging has demonstrated that aging affects the manner in which older adults perform social cognitive tasks (e.g., Blanchard-Fields & Beatty, 2005; Hess, Osowski, & Leclerc, 2005; Hess & Pullen, 1994; Horhota & Blanchard-Fields, 2006). However, it is poorly understood whether these observed differences result from age-related cognitive changes or from a secondary factor, such as different levels of life experience. Thus, it remains an open question whether the effects of aging on cognition are pervasive or whether they affect only specific cognitive systems. In the present article, we address this question by focusing on a discrete domain of social cognition that heavily engages executive function systems, specifically inhibition, the regulation of negative bias toward stigmatized individuals (Richeson et al., 2003; Richeson & Shelton, 2003).

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Older adults are impaired in cognitive tasks that require inhibition (e.g., Stroop and Wisconsin Card Sorting Task; Hasher & Zacks, 1988; Houx, Jolles, & Vreeling, 1993; Rhodes, 2004). Many of the same neural regions engaged in inhibition during cognitive tasks are also active in inhibiting negative bias (e.g., Richeson et al., 2003). However, emerging neuroimaging research has demonstrated that inhibiting negative bias also engages several discrete neural networks that are not active during inhibition in cognitive tasks (e.g., Cunningham et al., 2004; Krendl, Macrae, Kelley, Fugelsang, & Heatherton, 2006; Richeson et al., 2003). For this reason, investigating the effects of aging on inhibiting negative bias provides an ideal method with which to assess the pervasiveness of the effects of aging on cognitive decline. If age-related cognitive decline is pervasive, older adults should experience difficulty engaging inhibitory processes in regulating negative bias, as well as in other cognitive domains, such as memory.

In the present study, we utilized social neuroscience—in which novel techniques (e.g., neuroimaging) are used to investigate theoretical questions raised in social cognition, such as by identifying the processes underlying stereotype regulation—to explore the effects of aging on the neural mechanisms underlying the regulation of negative bias against stigma. Our primary goal in this study was to determine whether age-related cognitive decline extends into the social domain. In other words, does age-related cognitive decline impair older adults' ability to regulate negative bias toward stigma and, if so, how?

We chose to focus on stigma for two reasons. First, social interactions are a fundamental human need (Baumeister & Leary, 1995) that are pervasive across the life span. In everyday life we have numerous social interactions, and inevitably at least a few of these are with a stigmatized individual (e.g., someone who is homeless, obese, or disfigured). Thus, evaluating stigma is something with which older adults have had a lifetime of experience. Second, because stigma elicits automatic or unintentional negative stereotypical thought in most people (Devine, 1989), regulating negative bias is cognitively demanding and relies heavily on executive function systems (Payne, 2005; Richeson et al., 2003; Richeson & Shelton, 2003). For instance, Payne found that young adults with high automatic bias against a stigmatized target were more likely to express that bias if they had low executive control. In other words, individuals who do not have sufficient executive control express greater negative bias against stigmatized individuals because they lack the resources with which to successfully regulate their bias. Thus, if age-related cognitive decline impairs executive function systems that regulate negative bias, healthy older adults with more impaired systems should show greater negative bias than should healthy older adults with less impaired systems.

An important caveat to using social methods to address this question is that older adults may differ from younger adults in their performance on social tasks due to cohort differences and not to cognitive decline. In order to avoid this potential confound, we focused on the differences not only between the young and older adults but also between two groups of older adults: those with relatively preserved executive function capacities and those with relatively impaired executive function capacities. If older adults with relatively impaired levels of executive function have more bias and exert less effective neural regulation than do older adults with relatively preserved levels of executive function, this would

provide convincing evidence that age-related cognitive decline impairs older adults' ability to regulate negative bias. Additionally, if such differences emerge between the two groups of older adults, this would minimize concerns about potential age differences in levels of bias (i.e., do older adults start out with more bias than do young adults?) or motivation to control bias (i.e., are young adults more motivated than older adults to control bias?) because the two groups of older adults differ only in their level of executive function decline. Thus, differences that emerge between these two groups are most likely attributable to age-related executive function decline.

In the current study, we used functional magnetic resonance imaging (fMRI) to examine the effects of aging on regulating stereotypes, a process that relies heavily on executive function (Payne, 2005; Richeson et al., 2003; Richeson & Shelton, 2003). Because the neural processes supporting inhibition are well characterized, functional neuroimaging provides an excellent method with which to address this question. In particular, existing knowledge of the specific neural mechanisms engaged in inhibition and stereotype regulation provides a meaningful guideline for assessing whether aging alters which neural mechanisms are activated to regulate negative bias and the extent to which these structures are engaged.

Previous research suggests that perceiving stigma engages a discrete network of neural activity engaged in automatic and controlled responses, including the amygdala (an area implicated in responding to threatening stimuli; Whalen, 1998) and the anterior cingulate cortex and ventrolateral prefrontal cortex (which have been extensively implicated in inhibition and regulation; Konishi et al., 1999). The amygdala activity is believed to reflect an aversive response that is engaged automatically in response to stigma, and this response can be subsequently modulated by the engagement of prefrontal regions (e.g., the anterior cingulate cortex and ventrolateral prefrontal cortex; Cunningham et al., 2004). Indeed, activity in the ventrolateral prefrontal cortex has been shown to increase in response to increasingly aversive stigmas. This provides further evidence that perceivers engage these control areas to modulate their negative response to stigma (Krendl et al., 2006).

It is important to note, however, that executive control is not the only tool that perceivers use to regulate their negative bias. For instance, Galinsky and Moskowitz (2000) demonstrated that taking the perspective of a stigmatized target can minimize a perceiver's bias toward that individual. In a recent neuroimaging study, Harris and Fiske (2006) found that perceivers had heightened activation in the medial prefrontal cortex—a neural region implicated in mentalizing (i.e., perspective taking)—when they evaluated less aversive stigma groups (e.g., individuals with amputations) but not when they evaluated highly aversive stigma groups (e.g., the homeless). Harris and Fiske suggested that perceivers show heightened activity in response to less aversive stigmatized individuals because they are more likely to regulate their reactions to less aversive stigma groups (possibly because they feel more pity for those with less aversive stigmas than they do for those with more aversive stigmas). Although only general conclusions can be made about the meaning of these activations, two important points emerge from the extant neuroimaging research on stigma: (a) out-group members automatically elicit aversive responses (i.e., as indicated by activity of the amygdala) in perceivers and (b) per-

ceivers engage cognitive control mechanisms (i.e., as indicated by activity in lateral prefrontal cortex, anterior cingulate, and medial prefrontal cortex) to varying degrees to inhibit those aversive responses to stigmatized out-group members.

Given that successfully regulating negative reactions toward stigma requires cognitive control, it remains an open question whether older adults (who experience varying degrees of cognitive decline) can also successfully engage inhibitory mechanisms in order to regulate negative bias toward stigma. Von Hippel and colleagues (2000) found that older adults with relatively limited inhibitory ability had more negative bias toward a Black individual than did older adults with relatively preserved inhibitory ability. Due to the dearth of research on aging and stereotyping, we turned to the social cognition and aging literature, which suggests that older adults can alter their social judgments of nonstigmatized targets when sufficiently motivated (Hess, Rosenberg, & Waters, 2001). Further, older adults actively exert cognitive control in order to promote more positive affect and social interactions (Carstensen, Isaacowitz, & Charles, 1999; Mather & Carstensen, 2003, 2005). However, older adults hold individuals more accountable for their actions, particularly when the outcome of a social situation is negative (Blanchard-Fields & Norris, 1994). Thus, the social cognition and aging research suggests that older adults can regulate negative bias, but whether they will do so remains an open question.

By using social neuroscience to investigate the effect of aging on older adults' ability to regulate negative reactions toward stigma, we hope to provide insight into the extent to which aging impairs older adults' cognitive abilities (and therefore older adults' subsequent performance on cognitive tasks). The critical question in the current study was whether older adults with good executive function used different processes to regulate negative bias to stigmatized individuals than did older adults with poor executive function. If age-related cognitive decline did impair older adults' ability to regulate negative reactions, we anticipated that older adults who had experienced more cognitive decline would have less activity in neural areas associated with regulation (and subsequently have more bias) when they evaluated stigmatized individuals than when they evaluated older adults with relatively preserved cognitive function.

## Method

### *Participants*

In total, 42 neurologically normal right-handed older adults (OA; mean age = 73.14 years, 29 female) and 23 neurologically normal right-handed young adults (YA; mean age = 19.53 years, 12 female) were recruited to participate in this study. YA were Dartmouth undergraduates who were recruited with on-campus advertisements. OA were recruited from a rural New Hampshire community through newspaper and e-mail advertisements. Both OA and YA participated in exchange for monetary compensation. All OA underwent a health screening to ensure they did not have a physical condition that could affect cognitive function or brain activity (e.g., untreated high blood pressure, diabetes, history of stroke; Arvanitakis, Wilson, Li, Aggarwal, & Bennett, 2006; Heflin et al., 2005; O'Sullivan, Morris, & Markus, 2005; Srikanth et al., 2003).

Both OA and YA completed a battery of cognitive tests that assessed frontal lobe function. The tests included the Wisconsin Card Sorting Task, FAS word fluency, mental arithmetic from the Wechsler Adult Intelligence Scale—Revised, and mental control and Digit Scan Backward from the Wechsler Memory Scale—Revised (Glisky, Polster, & Routhieux, 1995). On the basis of the scoring procedure developed by Glisky et al. (1995) we assigned a weight to the individual's performance on each of these tasks and then combined these weights to determine the individual's executive function score. We conducted a median split on executive function scores to divide OA into two groups: high-functioning OA and low-functioning OA. All participants also completed the Motivation to Control Prejudice (Dunton & Fazio, 1997), which assessed differences in their respective explicit motivation not to appear prejudiced. Items directly referring to race were removed from the scale, but all other items remained (e.g., "In today's society, it is important that one not be perceived as prejudiced in any manner").

### *Imaging Procedure*

Anatomical and functional whole-brain imaging was performed on a 3.0T Phillips Intera Achieva Scanner (Phillips Medical Systems, Bothell, WA). An Apple G4 computer running Superlab 4 was used for stimulus display. Anatomical images were acquired with a high-resolution 3-D magnetization prepared rapid gradient echo sequence (60 sagittal slices, TE = 4.6 ms, TR = 9.9 ms, flip angle = 8°, 1 × 1 × 0.89-mm voxels). Functional images were collected in four functional runs of 144 time points each, using a fast field echo, echo-planar sequence sensitive to blood oxygen level dependent contrast (T2\*; 30 axial slices per whole-brain volume, 3-mm in-plane resolution, 4-mm thickness, 1-mm skip, TR = 2,500 ms, TE = 35 ms, flip angle = 90°).

### *Behavioral Task*

The study was modeled as a mixed-block and event-related design. Each functional run was divided into two blocks: one explicit judgment (evaluative) and one incidental judgment (gender). The gender judgment is defined here as being incidental, because perceivers were not being asked to express their conscious attitudes toward the stigmatized individuals in this condition. Thus, the incidental condition served as a means with which to assess neural activity unique to their implicit bias. In the explicit judgment block, participants were asked "Do you like or dislike this person?" and they pressed one button to indicate they liked the person and another button to indicate they disliked the person. In the incidental block, participants were asked "Is the person male or female?" and they pushed the corresponding button. Each trial lasted 2,500 ms (1 TR), and participants were free to respond at any point during this window. The order in which the blocks were presented was counterbalanced across participants and runs. Additionally, the judgments that were made on the pictures were counterbalanced across participants, such that equal numbers of explicit and incidental judgments were made on all pictures. Within each block, participants were presented with images of controls and images of the four stigma groups in an event-related fashion. Fixation trials were pseudorandomly intermixed with face trials in each block to permit event-related analysis (i.e., to allow

deconvolution of the hemodynamic signal unique to each trial). Interstimuli intervals ranged from 0 ms to 6,000 ms.

Participants viewed 360 images across the four functional runs. A total of 60 images was pseudorandomly presented for each of the four stigma groups (substance abusers, individuals with amputations, individuals with facial deformities, and the homeless), and an additional 120 images were presented of controls (i.e., individuals with no visible stigma). Images were high-resolution color pictures that were modified in Adobe Photoshop CS (Version 8.0) to be equally sized ( $360 \times 360$  pixels) with a resolution of 72 pixels/in. The images of the individuals with facial deformities were head shots only to ensure that the deformity was salient. The facial deformity images were of children who either had undergone a surgical procedure to repair a facial anomaly (e.g., cleft lip) or who had unrepaired facial anomalies. The images for the other stigma groups were selected from websites that contained images of people who were self-described members of one of the stigma groups (e.g., the homeless, individuals with an amputation) or were prepared by a group of undergraduates to ensure that they represented the intended stigma condition (e.g., individuals with alcoholism, drug addicts).

### Data Analysis

fMRI data were analyzed with the general linear model for event-related designs in SPM2 (Wellcome Department of Cognitive Neurology, London, UK). For each functional run, data were preprocessed to remove sources of noise and artifact. Functional data were corrected for differences in acquisition time between slices for each whole-brain volume, realigned within and across runs to correct for head movement, and transformed into a standard anatomical space (3-mm isotropic voxels) on the basis of the ICBM 152 brain template (Montreal Neurological Institute), which approximates Talairach and Tournoux's (1988) atlas space. Normalized data were then spatially smoothed (8 mm full width at half maximum) with a Gaussian kernel. Analyses took place at two levels: formation of statistical images and regional analysis of hemodynamic responses. A general linear model incorporating task effects for explicit and incidental task conditions and the five image types (substance abuser, individual with an amputation, individual with a facial deformity, homeless individual, and control), and covariates of no interest (a session mean, a linear trend, and six movement parameters derived from realignment corrections), was used to compute parameter estimates ( $\beta$ ) and t-contrast images (containing weighted parameter estimates) for each comparison at each voxel and for each participant.

In order to isolate neural activity that was unique to perceiving stigma, we extracted all contrasts of interest presented below from trials in which participants viewed any stigmatized face minus trials in which they viewed control (nonstigmatized) faces. These contrast images were used for all second-level random-effects analyses (e.g., conjunction analysis), which are described in detail in the Results section. Separate contrasts were conducted for the explicit and incidental conditions to identify any potential differences in neural activity by condition type.

Each contrast of interest (described in more detail in the Results section) revealed peak activations. We extracted average parameter estimates from these peak activations by using the contrast from each condition relative to baseline fixation to conduct a

region of interest (ROI) analysis. We used the condition versus baseline contrast for the ROI analyses, because this contrast, unlike the stigma versus control task, is unbiased. Thus, the unbiased mean signal changes extracted from the ROI analysis can be entered into an analysis of variance (ANOVA). ROIs were extracted with the functional ROIs tool in SPM2 (marsbar; Brett, Anton, Valabregue, & Poline, 2002). All significant voxels ( $p < .001$ ) within 6 mm of a peak location were included in each ROI. Because the amygdala is a punctate region, in this region only, the sphere was limited to voxels within 3 mm of the peak activation. An extent threshold of five contiguous activated voxels was also applied. Signal intensities for each ROI were examined statistically with a repeated-measures ANOVA.

### Results

We conducted a median split on the executive function scores of OA to assign them to either the low-functioning or the high-functioning group. Seven OA and five YA were excluded from further analysis due to excessive head motion ( $>4$ mm between successive EPI acquisitions) or scanner artifact. This left 18 YA, 17 low-functioning OA, and 18 high-functioning OA. Because neuroimaging research indicates that perceivers recruit distinct patterns of neural activation when evaluating stigmas that are perceived less negatively versus stigmas that are viewed more negatively (Harris & Fiske, 2006; Krendl et al., 2006), we subdivided the stimuli into three categories: the stigma groups that were perceived very negatively (substance abusers and the homeless), the stigma groups that were perceived less negatively (individuals with amputations or with facial deformities), and normal controls (images that had no overt stigma).<sup>1</sup> These three categories were used for all subsequent analyses. Further, no effect of condition (explicit vs. incidental) emerged in neural activity in any of the imaging analyses. We therefore collapsed across condition in all imaging analyses discussed below.

### Likability Ratings

Participants' responses on the explicit task were analyzed to identify potential group differences in expressed likability toward stigmatized individuals. For each participant, a mean proportion likability score was calculated for every stigma group. For instance, if a participant reported liking 9 of the 18 images of individuals with an amputation, she received a mean proportion score of .5 for that stigma group. First, we verified the validity of our stigma categories (stigmas perceived very negatively vs. stigmas perceived less negatively) by determining whether the likability scores were greater for individuals with stigmas that were

<sup>1</sup> Our selection of images of the less negative stigmas and more negative stigmas was based on extensive research in the stigma literature, which has shown that people with facial deformities and people with amputations are viewed more favorably than homeless people and substance abusers (Pryor, Reeder, Yeadon, & Hesson-McInnis, 2004; Schmidt & Weiner, 1988; Weiner, 1996). Recent imaging studies have confirmed these findings, adding that neural activity differs when perceivers see a homeless person as compared to a person with an amputation (Harris & Fiske, 2006). These studies suggest that homeless people are generally less liked and are viewed less favorably than people with an amputation.

perceived less negatively than for those with stigmas that were perceived more negatively. Indeed, all three groups (YA, high-functioning OA, and low-functioning OA) had significantly higher proportion liking scores in response to individuals with stigmas that were perceived less negatively than they did to individuals with stigmas that were perceived more negatively ( $p < .001$  for all).

Our primary objective in evaluating behavioral scores was to assess how well each group was able to inhibit its explicit dislike of stigma groups. The proportion liking scores were entered as the dependent variable into a 3 (image type: less negative, more negative, normal)  $\times$  3 (group: YA, high-functioning OA, low-functioning OA) ANOVA. A main effect emerged of image type,  $F(2, 94) = 245.72, p < .001$ , and group,  $F(2, 47) = 10.95, p < .001$ , but there was no Image Type  $\times$  Group interaction,  $F(4, 94) = 2.01, p = .1$ . Subsequent analyses demonstrated that high-functioning OA had higher proportion liking scores for individuals with the less negative stigmas ( $M = .94$ , standard error of the mean [SEM] = .02) than did the low-functioning OA ( $M = .82$ , SEM = .04) and YA ( $M = .78$ , SEM = .04,  $p < .01$  for both). However, high-functioning OA also had higher ratings for normal controls ( $M = .97$ , SEM = .01) than did low-functioning OA ( $M = .90$ , SEM = .02,  $p < .01$ ), who, in turn, had higher ratings for controls as compared to YA ( $M = .74$ , SEM = .03,  $p < .01$ ).

An important finding that emerged from this preliminary analysis is that OA and YA had different baselines in their likability ratings toward nonstigmatized individuals. In particular, OA rated normal controls as being more likable than did YA. Although these baseline rating differences (i.e., in the ratings given to normal controls) could be meaningful in suggesting differences in the way young and older adults perceive others, they could also be the consequence of differences in how young and older adults anchor their responses. For instance, older adults may be overall less likely than young adults to report that they significantly dislike someone. Thus, an important caveat that emerges from this finding is that older adults' proportion likability scores toward different stigma groups may be scaled differently than younger adults' scores. To circumvent this confound, we tried to standardize older and young adults' proportion likability scores by calculating a difference score for each participant (proportion likability of stigmas perceived less negatively minus portion likability of stigmas perceived very negatively).

We entered the differences score as the dependent variables in a one-way ANOVA, with group (YA, high-functioning OA, and low-functioning OA) as the between-subjects variable. The results from this one-way ANOVA revealed a main effect of group,  $F(2, 50) = 3.96, p < .03$ . Subsequent analyses revealed that the group effect emerged because both high-functioning OA and YA had significantly larger difference scores ( $M = .56$ , SEM = .04;  $M = .52$ , SEM = .05, respectively) than did low-functioning OA ( $M = .40$ , SEM = .06,  $p < .03$  for both comparisons) but did not significantly differ from each other ( $p = .8$ ). This finding suggests that low-functioning OA do not behaviorally distinguish less negative from more negative stigmas as strongly as do YA and high-functioning OA. Further, a Pearson's bivariate correlation between executive function and difference scores for OA revealed a positive correlation,  $r(34) = .42, p < .02$ . These results suggest that the higher functioning the older adult, the more he or she behaviorally dissociates between stigma groups.

### Motivation to Control Prejudice Results

All participants completed the Motivation to Control Prejudice (Dunton & Fazio, 1997). Items were reverse-scored in accordance with Dunton and Fazio's procedures. For each participant, a total score was calculated on the basis of his or her reverse-scored responses. Each participant's score was entered as the dependent variable into an ANOVA with group (YA, low-functioning OA, and high-functioning OA) as the between-subjects variable. ANOVA revealed no effect of group,  $F(2, 48) = 1.87, p = .17$ , and this suggests that the three groups did not differ in their explicit desire to control prejudice.

### Reaction Times

We examined reaction time data to address two key points: first, to verify that the explicit judgments were more effortful than the incidental judgments and, second, to determine if group differences emerged in reaction time data that may elucidate the behavioral responses (for a complete list of raw mean reaction times, see Table 1). With respect to the former, analyses revealed a main effect of condition,  $F(1, 50) = 66.47, p < .001$ , but only a trend for the Condition  $\times$  Group interaction,  $F(2, 50) = 2.74, p = .07$ . Subsequent analyses demonstrated that the main effect emerged

Table 1

Mean Reaction Times (in Ms) and Standard Errors of the Mean (SEM) for YA, High-Functioning OA, and Low-Functioning OA to Make Explicit and Incidental Judgments of Individuals With Less Negative Stigmas, Individuals With More Negative Stigmas, and Normal Controls

Reaction	YA		High-functioning OA		Low-functioning OA	
	<i>M</i>	<i>SEM</i>	<i>M</i>	<i>SEM</i>	<i>M</i>	<i>SEM</i>
Explicit, less negative	1,174.9	55.3	1,144.0	43.2	1,411.4	62.3
Explicit, more negative	1,268.7	53.7	1,493.0	50.8	1,640.3	54.7
Explicit, normal	1,127.8	52.8	1,073.0	42.2	1,264.4	40.1
Incidental, less negative	1,009.3	40.4	1,095.8	32.0	1,181.7	32.0
Incidental, more negative	1,052.4	39.2	1,297.1	42.3	1,367.7	30.7
Incidental, normal	931.7	34.8	1,007.8	27.3	1,114.6	32.0

Note. YA = young adults; OA = older adults.

because YA, high-functioning OA, and low-functioning OA were slower to make explicit judgments than they were to make incidental judgments for all image types ( $p < .04$ ), with one exception. High-functioning OA did not significantly differ in how long it took them to make incidental and explicit judgments of individuals with less negative stigmas. Further, for all participants and conditions, the images of normal controls were rated more quickly than were images of those with less negative stigmas, which in turn were rated more quickly than were images of those with more negative stigmas ( $p < .04$  for all).

In order to examine potential group differences in reaction times, we first converted all reaction times to  $z$  scores to account for age-related slowing in reaction time. Our main question in the group differences analysis was to determine if YA, high-functioning OA, and low-functioning OA differed in their respective reaction times (when controlling for age-related slowing) when they evaluated a stigmatized as compared to a nonstigmatized target. Thus, we first examined group differences at baseline (e.g., reaction times when YA and OA evaluated control images) to determine if the three groups had different baseline reaction times. Indeed, high-functioning OA had significantly faster reaction times when evaluating control images than did YA and low-functioning OA, regardless of condition ( $p < .05$  for all). Low-functioning OA had faster reaction times than YA for control images in the evaluative condition only ( $p < .001$ ).

Because our primary interest in examining the reaction times was to determine whether the three groups differed in their response times to stigmatized individuals only, we controlled for these baseline differences by computing difference scores as we did for the behavioral ratings reported above (i.e.,  $z$ -scored reaction time for less negative stigmas minus  $z$ -scored reaction time for more negative stigmas). Each participant then had one difference score for the explicit condition and one difference score for the incidental condition. We entered these difference scores into one-way ANOVAs (where each condition was run separately) with group as the between-subjects variable. Analyses revealed a main effect of group for both the explicit and the incidental condition ( $p < .001$  for both).

Subsequent analyses revealed that YA had at least marginally faster reaction times than did both high- and low-functioning OA in both the explicit and the incidental conditions ( $p < .1$  for all). High-functioning OA had faster reaction times than did low-functioning OA in the explicit but not the incidental condition ( $p < .01$  and  $p > .2$ , respectively).

The behavioral data suggest two main points: First, high-functioning OA and YA have relatively more favorable ratings of stigmas perceived less negatively than do low-functioning OA. Second, high-functioning OA and YA made these ratings faster than did low-functioning OA. However, YA were faster than high-functioning OA at making these judgments. Together these findings provide behavioral evidence that high-functioning OA and YA evaluate less negative stigmas in a qualitatively different manner than do low-functioning OA. However, the mechanism by which these differences occur remains unclear. Further, the lack of behavioral differences in ratings between YA and high-functioning OA does not necessarily imply that they use the same mechanisms to evaluate stigmatized targets. For instance, similar behavioral results could arise because one group has less bias than the other but the group with more bias exerts more regulatory effort to

overcome that bias. Indeed, the reaction time differences between these two groups provide at least suggestive evidence that these ratings may be more effortful for high-functioning OA than they are for YA. It is therefore difficult to accurately interpret these behavioral results in isolation, and we turn to the imaging results to elucidate these findings. The fMRI results identify the neural mechanisms engaged by all three groups when evaluating stigmatized targets. These data are thus crucial in interpreting these behavioral results.

### *Imaging Results: Activations Shared By YA, High-Functioning OA, and Low-Functioning OA*

We conducted a conjunction analysis (using the masking function in SPM2) to identify neural activity shared by YA, high-functioning OA, and low-functioning OA when they perceive stigma (i.e., regions revealed in all three groups for the contrast of stigmatized > control faces). To conduct the conjunction analysis, we thresholded the contrasts for YA and OA with a  $p$  value of .01 (leading to a joint probability of .001 using Fisher's estimate; Fisher, 1950) and a five-voxel extent threshold. The conjunction analysis revealed a large network of commonly activated regions (see Table 2), but of most interest to the present study were activations in the left fusiform gyrus, right anterior cingulate cortex (BA 8/32), bilateral BA 47, and bilateral amygdala (see Figure 1).

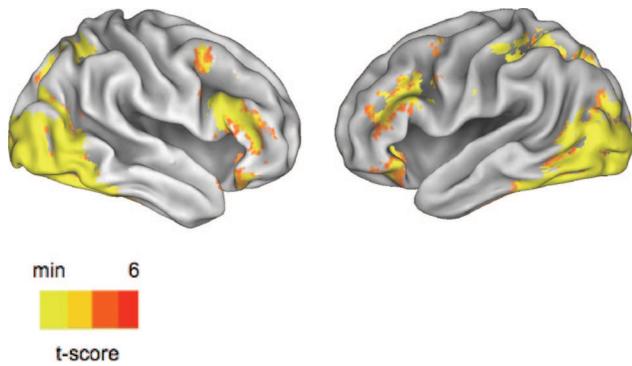
ROI analyses were conducted on all peak activations listed above to determine how each area responded to the three categories of images. The subsequent mean signal changes from each ROI were entered into a 3 (image type: more negative stigma, less negative stigma, controls)  $\times$  3 (group: YA, high-functioning OA, low-functioning OA) mixed ANOVA with image type as the within-subjects variable and group as the between-subjects variable. The ANOVA revealed a main effect of image type for the left amygdala, left fusiform gyrus, left BA 8/32, and right BA 47 (the inferior prefrontal cortex; all  $ps < .04$ ) and an Image Type  $\times$  Group interaction for left BA 47,  $F(4, 100) = 2.45$ ,  $p = .05$ .

Subsequent analyses revealed that the main effect of image type emerged because participants had stronger neural responses in these areas to stigmatized faces than to control images. For instance, in the fusiform gyrus, all participants showed a trend toward stronger activations in response to all stigmatized faces as

Table 2  
*Overlapping Neural Activation for YA, High-Functioning OA, and Low-Functioning OA for Stigma Face > Control Contrast*

Brain region	$x$	$y$	$z$	$t$ score
L. fusiform gyrus	-48	-57	-24	17.42
R. inferior frontal gyrus (BA 47)	30	24	-6	7.97
R. superior frontal gyrus (BA 6/8)	6	15	48	6.78
L. superior temporal gyrus (BA 38)	-57	15	-9	6.55
L. superior frontal gyrus (BA 6/8)	-30	0	51	6.59
Cerebellum	-21	-42	-51	5.43
R. amygdala	21	0	-21	3.88
L. amygdala	-18	0	-21	3.75

*Note.* Conjunction analysis show shared activations by young adults (YA) and older adults (OA) for any stigmatized face > control.  $p < .001$ , uncorrected, with five-voxel extent threshold. All coordinates Montreal Neurological Institute.



**Figure 1.** Conjunction analysis for YA, low-functioning OA, and high-functioning OA for stigma face > control contrast. An inflated voxel-by-voxel cortical rendering of the left and right hemispheres with a minimum threshold set at  $T = 3.5$  and maximum set at  $T = 6$  for  $p < .001$  uncorrected, 5-voxel extent threshold, for the conjunction analysis of stigmatized participants versus controls. Results revealed that YA, high-functioning OA, and low-functioning OA exhibited heightened activation in the bilateral amygdala and bilateral inferior prefrontal cortex (BA 44 and BA 47) for stigma face > control. YA = young adults; OA = older adults.

compared to nonstigmatized faces (YA =  $p < .09$ ; high-functioning OA =  $p < .06$ ; low-functioning OA =  $p < .06$ ). In the left amygdala, however, this effect was significant only for YA ( $p < .03$ ) and not for the OA groups ( $p > .1$ ).

In the inferior prefrontal gyrus, participants' neural response was generally greater in response to less negatively perceived stigmatized faces as compared to more negatively perceived stigmatized and nonstigmatized faces. For instance, in left BA 47 (the inferior prefrontal cortex), both high- and low-functioning OA exhibited heightened activation in response to less negative stigmatized faces as compared to normal faces and more negative stigmatized faces ( $p < .05$  for both), although this effect was significant only for high-functioning OA ( $p < .05$ ). YA did not show any dissociation in neural activity in this area in response to any face type.

These results suggest that all participants experienced heightened activation in neural regions associated with automatic processing (i.e., amygdala and left fusiform gyrus) in response to any stigmatized face. However, they also showed heightened activity in regions associated with controlled processing (i.e., inferior prefrontal cortex) in response to stigmatized faces, and certain areas (left BA 47) selectively activated more in response to less negative stigmatized faces. Next, we sought to identify age differences in neural activity.

#### *Imaging Results: Age Differences in Prefrontal Activations in Response to Less Negative Stigmatized Faces*

In order to isolate any neural activity observed for high-functioning OA that was different from activity observed in YA and low-functioning OA, we conducted separate analyses using the masking function in SPM to exclude activity from YA and from low-functioning OA, respectively, to isolate neural activity unique to high-functioning OA. In these analyses, the cluster extent threshold was set at  $p < .001$ , with five voxels for both the

excluded contrast and the contrast of interest. We conducted a similar analysis to identify neural regions uniquely activated by YA and not by high- or low-functioning OA. In the following sections, all ROIs were extracted from peak activations that emerged in these newly formed contrasts.

In order to determine to what extent, if any, age-related cognitive decline impairs cognitive capacity, we focused our analyses of group differences in neural activity on the prefrontal cortex, as it has been largely implicated in regulation and inhibition (Konishi et al., 1999). In particular, we wanted to determine if high-functioning OA and YA had higher activity in neural areas engaged in inhibition than did low-functioning OA. We had predicted that if executive function decline interferes with the ability of OA to regulate negative bias, low-functioning OA should have less activity in prefrontal neural mechanisms associated with regulation and inhibition than should high-functioning OA because the former have fewer resources to devote to the task.

#### *High-Functioning OA > Low-Functioning OA and YA*

The masking analysis demonstrated that high-functioning OA activated certain regions of the inferior prefrontal cortex more extensively than did YA or low-functioning OA. In particular, they activated several bilateral prefrontal cortical regions associated with regulation more strongly than did YA and low-functioning OA (i.e., left BA 44, bilateral BA 45, left BA 47, and left BA 46/10). For a complete list of activations, see Table 3. One important observation is that many of the areas in the inferior prefrontal cortex implicated in this analysis also emerged in the conjunction analysis. This suggests that although YA, high-functioning OA, and low-functioning OA all engaged these regions when perceiving stigmatized faces, high-functioning OA recruited them more.

In order to more closely examine these activations, we entered the mean signal changes extracted from these regions into a 3 (image type: more negative stigma, less negative stigma, control)  $\times$  3 (group: YA, high-functioning OA, low-functioning OA) mixed ANOVA, with condition and image type as the within-

**Table 3**  
*Neural Activation That Was Greater for High-Functioning OA Than for YA or Low-Functioning OA for Stigma Face > Control Contrast*

Brain region	x	y	z	t score
L. inferior frontal gyrus (BA 45)	-54	33	15	7.08
R. inferior frontal gyrus (BA 11)	30	21	-27	6.89
L. inferior frontal gyrus (BA 46/10)	-39	42	0	6.66
L. inferior frontal gyrus (BA 47)	-33	27	-12	6.4
R. inferior frontal gyrus (BA 45)	36	24	9	6.39
R. cerebellum	21	-66	-45	5.96
L. cerebellum	-39	-48	-39	5.79
R. insula	24	15	0	5.69
L. thalamus	-18	-12	12	4.82
L. inferior frontal gyrus (BA 44)	-48	9	27	4.77

*Note.* Analyses showing shared activations by young adults (YA) and older adults (OA) for any stigmatized face > control.  $p < .001$ , uncorrected, with five-voxel extent threshold. All coordinates Montreal Neurological Institute.

subjects variables and group as the between-subjects variable. ANOVAs revealed a main effect of group and of image type for right BA 45,  $F(2, 50) = 3.55, p < .04$ ;  $F(2, 100) = 4.89, p < .01$ , respectively, and for left BA 44,  $F(2, 50) = 3.44, p = .04$ ;  $F(2, 100) = 4.24, p < .02$ , respectively. Left BA 47 revealed no effect of image type or group but did reveal an Image Type  $\times$  Group interaction,  $F(2, 100) = 2.45, p = .05$  (see Figure 2a). Left BA 46/10 revealed an effect of group,  $F(2, 50) = 7.12, p < .005$  (see Figure 2b) but no effect of image type and no interaction ( $F_s < 1$ ).

The main effects of group were driven largely by the fact that high-functioning OA recruited more activity from these regions than did YA and low-functioning OA in response to viewing less negative stigmatized faces. For instance, high-functioning OA showed more activity in right BA 45 and left BA 44 than did YA ( $p < .05$  for all) in response to viewing less negative stigmatized faces. They recruited left BA 46/10 more than did low-functioning OA and YA across all image types ( $p < .05$  for all). They also

recruited left BA 47 to a greater extent than did low-functioning OA and YA when evaluating less negative stigmatized faces, although the effect was significant only for the comparison to YA ( $p < .03$ ). Together, these results suggest that high-functioning OA recruited activity from the inferior prefrontal cortex to a greater extent than did low-functioning OA or YA. This finding is consistent with our a priori hypothesis. Next, we examine regions that were more extensively recruited by YA than by OA.

#### YA > High-Functioning and Low-Functioning OA

Preliminary examination of the areas activated by YA, but not by high- and low-functioning OA, revealed a significant increase in activation only in left BA 8 ( $-12\ 45\ 51$ ), an area implicated in mentalizing and empathy. A 3 (image type: less negative, more negative, control)  $\times$  3 (group: young adults, high-functioning OA, low-functioning OA) ANOVA revealed a main effect of image

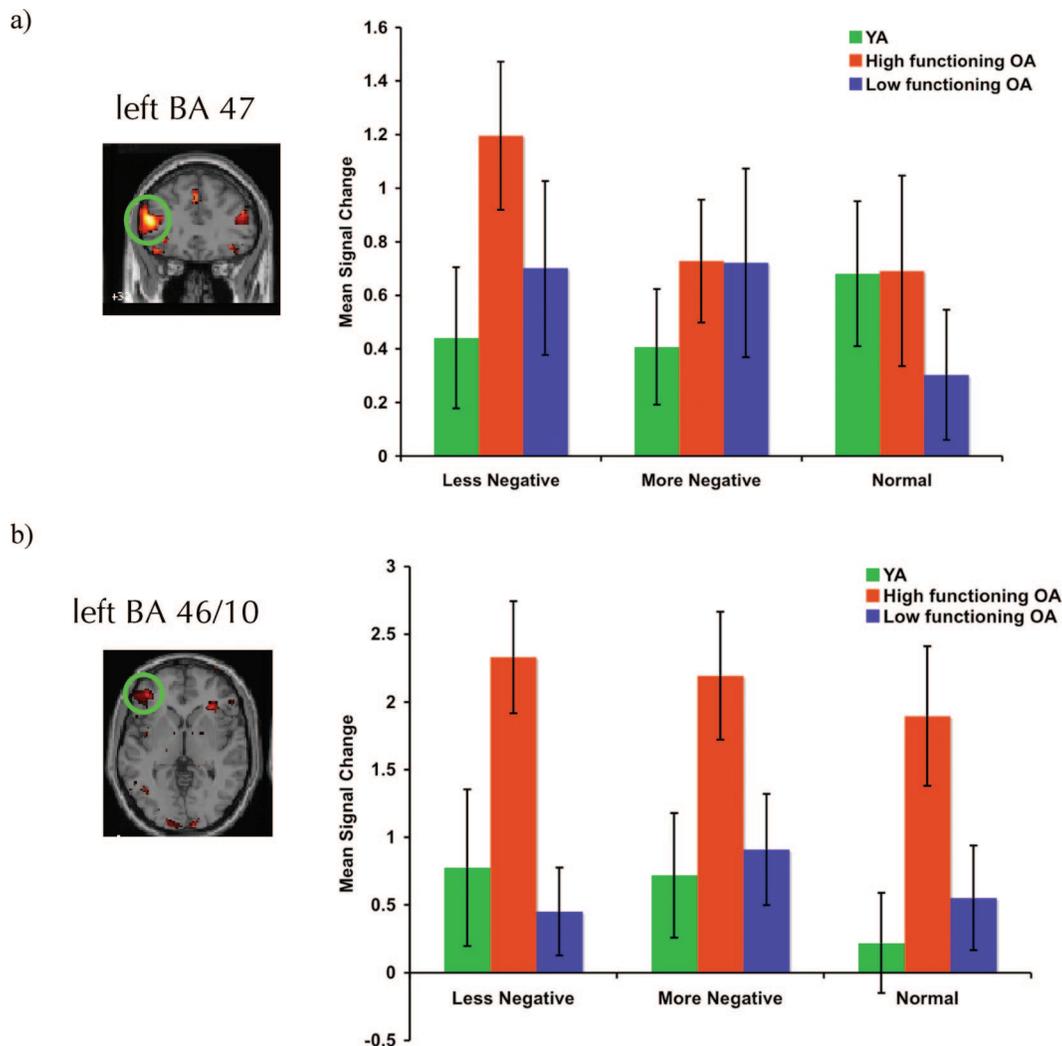


Figure 2. High-functioning OA exhibited heightened activity in response to stigmas that were perceived less negatively (noted on the graph as “less negative”) or stigmas that were perceived more negatively (noted on the graph as “more negative”) in BA 47 (a) and BA 46/10 (b) as compared to YA and low-functioning OA. YA = young adults; OA = older adults.

type,  $F(2, 100) = 4.87, p = .01$ , and group,  $F(1, 50) = 3.95, p < .03$ , but only a trend toward an Image Type  $\times$  Age interaction,  $F(4, 100) = 2.19, p = .08$ . A closer examination of the group effects demonstrated that the effect was driven by the fact that YA recruited significantly more activity from BA 8 than did low-functioning OA in response to viewing images of individuals with less negative stigmas or nonstigmatized controls ( $p < .01$ ), but the recruitment of high-functioning OA in BA 8 fell between that of the other two groups and did not significantly differ from that of either YA or low-functioning OA.

#### *Imaging Results: Individual Differences in Neural Activity Among OA*

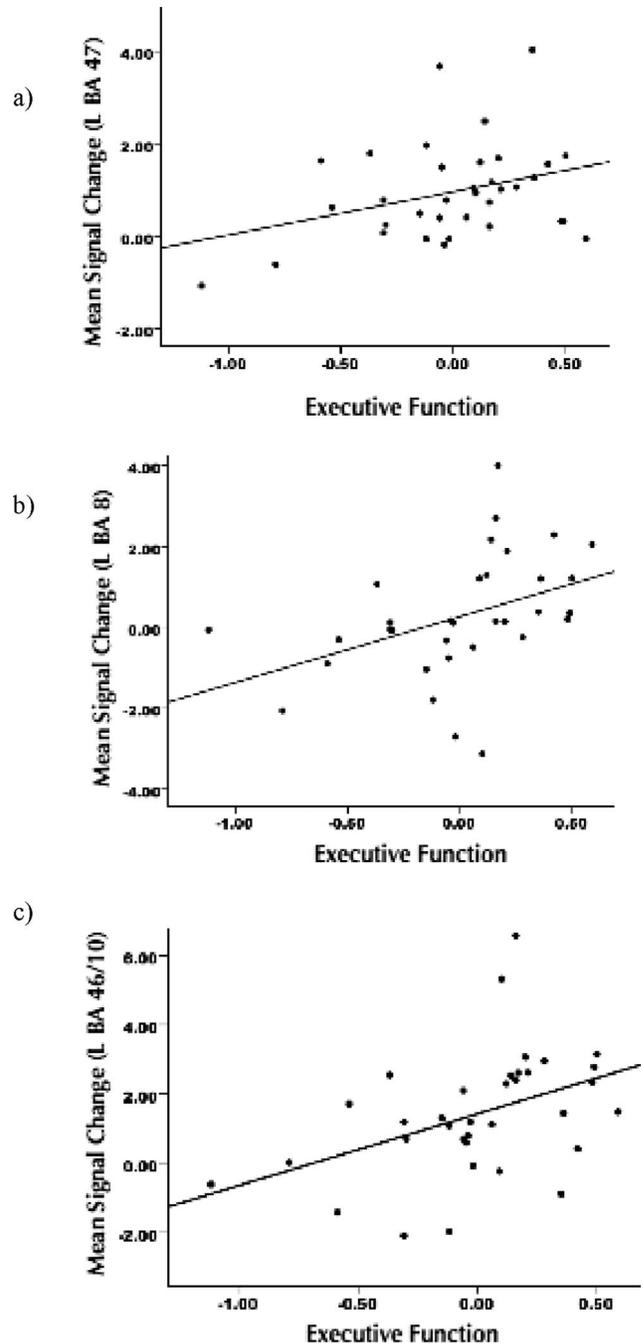
In order to identify whether differences in neural activity among OA were correlated with executive function, we conducted a Pearson's bivariate correlation comparing executive function with activity in the neural regions where group differences emerged (left BA 44, right BA 45, left BA 46/10, left BA 8, and left BA 47) in response to less negative stigmatized faces. Results revealed that, for OA, executive function was not related to activity in left BA 44 or right BA 45, but it was positively correlated with activity in left BA 47,  $r(35) = .33, p = .05$  (see Figure 3a); left BA 8,  $r(33) = .41, p < .02$  (see Figure 3b); and left BA 46/10,  $r(35) = .43, p = .01$  (see Figure 3c). This correlation suggests that OA with higher executive function recruited left BA 47, left BA 8, and left BA 46/10 in response to less negative stigmatized faces more than did OA with lower executive function scores.

Together, these findings provide partial support for our hypothesis: High-functioning OA recruited prefrontal cortical areas (i.e., left BA 47, left BA 46/10, and left BA 8) to a greater extent than did low-functioning OA when evaluating less negative stigmatized faces.

#### Discussion

The results of this study suggest that age-related declines in executive function interfere with older adults' abilities to regulate negative bias toward stigmatized individuals. Although YA, high-functioning OA, and low-functioning OA all showed activity in neural mechanisms that have been extensively implicated in evaluating stigmatized targets (e.g., amygdala, prefrontal cortex), they also exhibited strong differences in the extent of activity in cortical regions associated with regulation and inhibition. High-functioning OA activated areas of the lateral prefrontal cortex more than did YA and low-functioning OA, whereas YA had greater activity in the medial prefrontal cortex than did OA in response to viewing faces of less negative stigma groups. Given that high-functioning OA and YA expressed similar explicit attitudes toward stigmatized targets, the differences in the two groups' neural activity provide suggestive evidence that high-functioning OA and YA relied on different underlying processes to achieve similar behavioral results.

One distinct possibility that emerges from these findings is that high-functioning OA may have exerted greater cognitive effort in order to achieve the same behavioral result as did YA. Evidence of this supposition is reflected in high-functioning OA's heightened recruitment of activity from the left lateral cortex (BA 47, BA 46/10), a region previously implicated in



*Figure 3.* Correlation for OA between executive function score and mean activity in response to stigmas that are less negatively perceived in (a) BA 47, (b) BA 8, and (c) BA 46/10. For each region, neural activity is positively correlated with executive function.

inhibiting negative reactions to stigma (Lieberman, Hariri, Jarcho, Eisenberger, & Bookheimer, 2005; Richeson et al., 2003). Indeed, several studies have shown that automatic responses to stigma (like those elicited by the amygdala) are regulated (i.e., inhibited) by higher order cognitive processes (e.g., areas in the prefrontal cortex; Cunningham et al., 2004; Harris & Fiske,

2006; Krendl et al., 2006). High-functioning OA's heightened engagement of BA 46/10 in response to all stimuli as compared to that of low-functioning OA and YA is particularly intriguing, as this area has previously been implicated in the control and regulation of reactions to emotional stimuli (Ochsner, Bunge, Gross, & Gabrieli, 2002). This finding suggests that high-functioning OA may be monitoring their emotional response to the images throughout the task.

Why might high-functioning OA be exerting cognitive resources to monitor their response? Most likely, high-functioning OA have more activity in the lateral prefrontal cortex than do low-functioning OA because they have more cognitive resources available to devote to the task. By definition, low-functioning OA have a paucity of cognitive resources, and thus they should be more miserly in the extent to which they devote those resources to cognitively demanding tasks. Indeed, previous research has demonstrated that age-related cognitive decline impairs everyday complex cognitive thinking. For instance, OA who have experienced greater declines in fluid intelligence (which is a direct measure of executive function capacity) rely on simplified strategies for making decisions about health, finance, and nutrition (Broder, 2003; Finucane, Mertz, Slovic, & Schmidt, 2005; Mata, Schooler, & Rieskamp, 2007). Unfortunately, these strategies tend to be less effective (i.e., OA are less likely to identify which HMO would provide the best treatment on the basis of reviewing survey data because this requires advanced cognitive processing; Finucane et al., 2005; Gigerenzer, 2003; Sanfey & Hastie, 1999). However, it is believed that low-functioning OA employ these seemingly less effective strategies because such strategies reduce the amount of cognitive effort they need to expend on a given task.

It is important to note that the fact that high-functioning OA have higher activity in BA 46/10 than in low-functioning OA, regardless of image type, negates the possibility that the relatively small neural response of low-functioning OA to the less negative stigmas was related solely to their less favorable behavioral responses. High- and low-functioning OA had comparable behavioral responses toward the normal faces but different patterns of neural activity. We have suggested that these different patterns of activity may reflect the heightened cognitive effort of high-functioning OA as compared to YA and low-functioning OA to regulate negative bias. However, two caveats must be considered in tandem with this supposition. First, the present study was designed to measure *if*, not *why*, high- and low-functioning OA differed in their respective recruitment of neural activity to regulate negative bias. Second, it is difficult to interpret from these results what low-functioning OA are doing in this task. Although results from the Motivation to Control Prejudice scale suggest, at least implicitly, that low-functioning OA are as motivated as high-functioning OA not to appear prejudiced, it is also possible that low-functioning OA may be less conscious of stereotypes or may be implicitly less motivated to control them. Future research should directly address these caveats.

If, as we have argued, heightened activity in the lateral prefrontal cortex is synonymous with increased regulatory efforts, it may seem surprising at first glance that high-functioning OA recruited more activity in these regulatory areas than did YA, who possess overall higher executive function capacity than do OA (Salthouse & Miles, 2002; Uekermann, Channon, & Daum, 2006). However,

these findings are consistent with emerging evidence from cognitive neuroscience that has shown that older adults have more widespread patterns of neural activity while performing cognitive tasks than do young adults (Cabeza et al., 2002). One explanation for this finding is that older adults may recruit more neural activity to compensate for cognitive systems that do not work as efficiently as those of YA (for a review, see Cabeza, 2002). Thus, with respect to our findings, YA may require less activity from these inhibitory areas than do high-functioning OA to effectively regulate their negative bias because the brains of YA work more efficiently. In other words, if YA have more efficient connections than do OA between the amygdala and prefrontal cortex, their prefrontal response will be more effective at inhibiting the amygdala response and thereby at modulating their aversive response. Indeed, OA have significantly less white and gray matter volume than do YA (Salat, Kaye, & Janowsky, 1999), and white matter volume declines rapidly among OA (Double et al., 1996). Moreover, Cook, Bookheimer, Mickes, Leuchter, and Kumar (2007) recently demonstrated that OA have less white matter connectivity between amygdala and orbitofrontal cortex than do YA. Although these findings do not extend to the lateral prefrontal gyrus, they provide some encouragement for the assertion that, compared to YA, OA may have less effective connectivity between the amygdala and prefrontal cortex. Future connectivity studies will inform these findings, as will studies that can better capture potential temporal differences in neural activity (i.e., event-related potentials).

An alternate explanation for why high-functioning OA recruited greater activity from the lateral prefrontal cortex than did YA is that YA may have relied on other strategies to minimize their bias (e.g., mentalizing about their targets). Mentalizing allows us to infer the intentions of others so we can accurately interpret their behavior (Gallagher & Frith, 2003). YA demonstrated heightened activity in the medial prefrontal cortex (i.e., BA 8), an area that has been implicated in empathizing (Vollm et al., 2006) and mentalizing (Berthoz, Armony, Blair, & Dolan, 2002; Gallagher & Frith, 2003; Stuss, Gallup, & Alexander, 2001). Although it remains an open question whether mentalizing is more effective than inhibition as a strategy for regulating negative bias, compelling evidence has demonstrated that mentalizing is highly effective in reducing a perceiver's negative bias toward a stigmatized target (Galinsky & Moskowitz, 2000).

Finally, we must also consider the possibility that cohort differences may account for why high-functioning OA recruited greater activity from the lateral prefrontal cortex than did YA. YA grew up in a much more "politically correct" age than did OA. As a result, inhibiting bias may be almost second nature to YA and therefore demands less cognitive effort. Alternatively, with modern society's increased emphasis on diversity, YA may have been exposed to a greater number of stigmatized individuals than were OA, and this may have resulted in YA being relatively desensitized to stigma. It is important to note that although this explanation may elucidate the differences we observed between YA and OA, cohort differences cannot account for the fact that high-functioning OA recruited more activity from the lateral prefrontal cortex than did low-functioning OA.

We have argued that the findings from this study support the supposition that OA may underperform on cognitive tasks relative to YA because OA lack sufficient cognitive resources. By using

neuroimaging to investigate this question, we were able to determine that although high-functioning OA and YA had similar explicit behavioral responses to stigmatized targets, they relied on different neural mechanisms to make those evaluations. This finding gives important insight into the potential effects of aging on the neural mechanisms underlying perceiving stigma. A strength of this study is that we were able to compare neural activity of high- and low-functioning OA and found positive correlations between executive function capacity and neural activity in regulatory areas. However, a potential limitation to this supposition is that the observed differences between high- and low-functioning OA may be tangentially related to a different cause that happens to be related to executive function, such as socioeconomic status. Future research should investigate this question.

Together, these findings contribute to the growing social neuroscience literature on person perception. Extending previously reported work examining how young adults perceive stigma, these results indicate that the network of activations observed in this study may reflect a more general neural response associated with negative social evaluations that are pervasive across the life span. These findings demonstrate that this network of regions responds to stigma irrespective of age and indicate that the response to stigma is obligatory and automatic across the life span. Finally, these findings suggest that declines in executive function over the life span affect a broad range of cognitive domains, including the ability to regulate negative responses against the stigmatized. As a result, age-related cognitive decline may lead to increased bias against stigmatized individuals.

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