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BRIEF REPORT

Older Adults' Decoding of Emotions: Role of Dynamic Versus Static Cues and Age-Related Cognitive Decline

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Although age-related deficits in emotion recognition have been widely explored, the nature and scope of these deficits remain poorly understood. We conducted two experiments to examine whether these deficits are less pronounced when older adults evaluate dynamic compared with static images, and second, whether age-related cognitive decline exacerbates these deficits. Our results suggest that age-related cognitive decline exacerbates older adults' deficits in detecting anger, but only from static faces. Furthermore, older adults do not show emotion recognition deficits when evaluating global emotions from dynamic images of faces.

Keywords: aging, social emotions, executive function, cognitive decline

Successful social interactions rely on an ability to accurately interpret target's emotions (Carton, Kessler, & Pape, 1999; Cooley & Nowicki, 1989; DePaulo, 1992; Feldman, Philippot, & Custrinim, 1991; Nowicki & Duke, 1994b), a task at which older adults are notably impaired (for a review, see Ruffman, Henry, Livingstone, & Phillips, 2008). In the current article, we examine a potential mechanism that may lead to these deficits—age-related cognitive decline—and explore the contexts in which these deficits are most pronounced.

It has been widely demonstrated that older adults have more difficulty than young adults in identifying negative social emotions (such as anger, fear, and sadness; Brosgole & Weisman, 1995; Calder et al., 2003; Keightley, Winocur, Burianova, Hongwanishkul, & Grady, 2006; Ruffman et al., 2008). However, there is not a clear understanding as to why that might be (for review, see Ruffman et al., 2008). One possibility for older adults' emotion recognition deficits is that they may pay less attention to images portraying negative emotions (e.g., Carstensen, Isaacowitz, & Charles, 1999). Indeed, older adults tend to avoid looking at negative, but not positive, facial expressions (Isaacowitz, Wadlinger, Goren, & Wilson, 2006; Mather & Carstensen, 2003). Thus, older adults may be impaired at recognizing negative emotions because they do not fully attend to them.

Alternatively, age-related cognitive decline may impair older adults' ability to accurately interpret emotional information (for review, see Ruffman et al., 2008). Healthy aging has a deleterious effect on frontal lobe function (Cabeza, 2001; Raz et al., 2005), which is critical for recognizing certain negative emotions, specifically anger (Adolphs, 2002; Blair & Cipolotti, 2000; Blair & Curran, 1999; Murphy, Nimmo-Smith, & Lawrence, 2003; Sprengelmeyer, Rausch, Eysel, & Przuntek, 1998). If age-related cognitive decline underlies older adults' deficits in interpreting negative social emotions, then older adults who have experienced a greater degree of frontal lobe decline should be more impaired at identifying negative social emotions (e.g., anger) that rely on the frontal lobes.

Finally, these deficits may emerge because of the modalities in which they have been measured. Specifically, the majority of the studies conducted to date have asked older adults to categorize discrete emotions from static facial expressions (e.g., Isaacowitz et al., 2007; Sullivan & Ruffman, 2004). However, when older adults evaluate social emotions in everyday life, they receive much more information from their targets than is conveyed by a simple static image (e.g., dynamic nonverbal cues, body language, changes in tone of voice). Indeed, research with young adults has shown that young adults are more accurate on emotion recognition tasks when evaluating dynamic compared with static stimuli (Bassili, 1979). Emotion recognition research with older adults that uses dynamic emotional stimuli has had mixed results (for review, see Ruffman et al., 2008), perhaps because these studies typically present dynamic auditory information or body cues without including other modalities such as dynamic facial cues.

To investigate the mechanisms underlying emotion recognition deficits, we conducted two experiments using well-validated measures of emotion recognition to evaluate older adults' emotion recognition performance. The measures used both static and dynamic images to assess whether emotion recognition deficits vary by modality. Furthermore, we also investigated whether age-related cognitive decline exacerbated older adults' deficits in emotion recognition. To this end, we compared the performance of older adults with relatively preserved frontal lobe functioning with that of older adults with relatively impaired frontal lobe functioning.

In our first experiment, we evaluated whether older adults' emotion recognition deficits in identifying discrete emotions (e.g., fear, anger, sadness, happiness) from static images of faces were exacerbated by executive function decline. In Experiment 2, we used a widely validated measure of global emotion recognition

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from dynamic visual images presented across multiple modalities (e.g., auditory, face only, body only) to determine whether executive function decline affected older adults' ability to accurately categorize emotions on various dynamic modalities.

Experiment 1

In our first experiment, we used the Diagnostic Analysis of Nonverbal Ability 2 (DANVA2), a well-validated measure for identifying discrete social emotions (e.g., happiness, sadness, fear, and anger; Nowicki & Duke, 1994a). The DANVA2 presents social stimuli displaying discrete emotions in a static (adult faces) presentation. While older adults have been found to be impaired relative to young adults at identifying discrete negative social emotions from static stimuli, it remains an open question as to whether these deficits are exacerbated by executive function decline (for review, see Ruffman et al., 2008). We will examine this question in Experiment 1.

Method

A total of 42 older adults (M_{age} = 75.8 years, 29 women) and 36 young adults (M_{age} = 19.8 years, 21 women) completed the adult faces portion of the DANVA2. Young adults were Tufts undergraduates who participated for monetary compensation or in exchange for course credit. Older adults were recruited from the Boston community through newspaper and e-mail advertisements. All older adults underwent a health screening to ensure they did not have a physical affliction that could affect cognitive function (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).

Procedure. Older adults completed a battery of cognitive tests to assess frontal lobe function that included: the Wisconsin Card Sorting Task, FAS word fluency, mental arithmetic from Wechsler Adult Intelligence Scale Revised (WAIS-R), Wechsler Memory Scale Revised (WMS-R) mental control, and WMS-R backward digit span (Glisky, Polster, & Routhieaux, 1995).[1] Based on the scoring procedure developed by Glisky and colleagues (1995), an individual's performance on each task was given an assigned weight and then z-scored to determine his or her overall executive function score. We conducted a median split based on the executive function scores to identify older adults who were relatively high in their executive function capacity (i.e., high functioning older adults) and older adults who were relatively low in their executive function capacity (i.e., low functioning older adults).[2]

On the DANVA 2 adult faces task, participants were presented with 24 static photographs of men and women making happy, sad, angry, or fearful expressions. Each face was presented on the screen for 2 seconds, following which participants were asked to indicate via button press whether the person pictured had been conveying happy, sad, angry, or fearful emotions.

Results

We conducted a 4 (affect: happy, sad, fearful, angry) × 2 (age: young vs. older adult) repeated-measures analysis of variance (ANOVA) using each participant's accuracy score on each affect category (see Table 1 for means). The ANOVA revealed a main effect of affect, $F(3, 219) = 28.29$, $p < .001$, and age, $F(1, 73) = 34.64$, $p < .001$, but no interaction, $F(3, 219) = 1.83$, $p > .1$.

Table 1
Participant Diagnostic Analysis of Nonverbal Ability 2 (DANVA2) Performance

Adult faces	Young adults	High functioning older adults	Low functioning older adults
Happy	0.94 (.02)	0.89 (.03)	0.88 (.02)
Sad	0.81 (.03)	0.71 (.04)	0.68 (.04)
Angry	0.77 (.02)	0.69 (.04)	0.53 (.06)
Fearful	0.78 (.02)	0.63 (.05)	0.58 (.06)

Note. Mean proportion correct by emotion type by young adults, high functioning older adults and low functioning older adults on the DANVA2 adults faces. SEM noted in parentheses.

To interpret these results, we conducted post-hoc *t*-tests on the relevant significant effects. Results revealed that, consistent with previous research, older adults were significantly less accurate on the adult faces task compared with young adults in accurately interpreting all negative emotions (anger, fear, and sadness; $p < .01$ for all), as well as the positive emotion happiness ($p < .05$).

Our central question was whether age-related executive function decline exacerbated older adults' impairments in accurately identifying negative emotions. We thus used *t*-tests to directly compare high and low functioning older adults overall accuracy on each affect category for the adult faces task. Low functioning older adults made more errors than high functioning older adults in identifying angry faces ($p = .02$; see Table 1 for mean accuracies on both tests). Furthermore, a Pearson's bivariate correlation between executive function and accuracy for correctly recognizing anger on the adult faces task revealed a significant correlation, $r(38) = .44$, $p < .01$. This finding provides converging evidence with the *t*-test, showing that as executive function increases among older adults, so too does their accuracy for identifying angry facial expressions.

Discussion

The results from Experiment 1 suggest that age-related cognitive decline exacerbates older adults' deficits at recognizing anger from static images, but it does not affect their ability to recognize any other emotion from static images. It is important to note that older adults were impaired relative to young adults in their overall accuracy in judging negative and positive discrete emotions on the adult faces task, a finding that is consistent with previous research (for review, see Ruffman et al.). However, these deficits for all

[1] Since the cognitive tests are time consuming, we only administered them to older, and not young, adults. The young adults who participated in these experiments were college students at a highly competitive Northeastern university, and are therefore relatively high functioning.

[2] We included a large sample of older adults in this study both to allow us to examine differences between high and low functioning older adults, and also to ensure that the median split was not biased toward individual's clumping in the middle. Z-scored executive function scores included a wide array of scores ranging from .65 standard deviations below the mean to .65 standard deviations above the mean.

other emotions were not intensified by age-related cognitive decline. These results suggest that older adults' general emotion recognition deficits may not be attributable to age-related cognitive decline.

It is important to note that Experiment 1 only used static visual information. Thus, in Experiment 2, we examined whether age-related cognitive decline affected older adults' ability to categorize emotions from dynamic visual targets, such as faces. This measure allowed us to more closely evaluate the effects of aging and age-related cognitive decline on older adults' ability to accurately decode more general emotion information from a variety of dynamic stimuli.

Experiment 2

The Profile of Nonverbal Sensitivity (PONS; Rosenthal, Hall, DiMatteo, Rogers, & Archer, 1979) is a well-validated measure of nonverbal behavior consisting of short video clips that present information visually, auditorily, or a combination of both. The clips are presented across multiple domains (i.e., perceivers only see the target's face or body) and convey either positive or negative affective information. Importantly, all domains present dynamic information (i.e., a 2-s video clip). This format allowed us to determine whether older adults' emotion recognition deficits were minimized during evaluations of dynamic images, such as faces.

We focused on recognition of positive and negative global emotions instead of discrete emotion recognition in this task to prevent the task from becoming too cumbersome for older adults. Since our primary question in Experiment 2 was to determine whether aging and age-related executive function decline affect older adults' ability to decode emotion information from different dynamic modalities, we focused on global emotion recognition only. The PONS includes separate channels to assess both auditory and visual emotion recognition. Our primary interest was to determine the effects of aging on recognizing global emotions from dynamic visual images (i.e., faces), but we also report the results from the auditory channels.

Method

A total of 44 older adults (25 women, $M_{age} = 75.5$ years, $SD = 5.9$ years) and 36 young adults (21 women, $M_{age} = 19.5$ years, $SD = 1.2$ years) participated in this experiment. Participant recruitment and assessment of executive function followed the same methods as described in Experiment 1. We used a shortened version of the PONS test that presents 110 audio and/or video clips, each lasting 2 s. The video clips present information via the face only, the body only, or the full figure (head and body). The audio clips were either content filtered (to remove the higher frequencies on which word recognition depends) or randomly spliced (to rearrange segments of the voice in a random manner). Six other channels combine audio and video cues resulting in 11 channels total. Each of the 110 clips conveys nonverbal information that is either positive or negative and also dominant or submissive. This results in four affective quadrants: positive-submissive (e.g., expressing gratitude), positive-dominant (e.g., talking to a lost child), negative-submissive (e.g., asking forgiveness), and negative-dominant (e.g., criticizing someone for being late).

Participants watched each clip and were asked to select between two responses pertaining to what the clip they had just seen or heard was about (e.g., describing nature, or talking to a lost child). Each set of responses was unique for every clip. Data were assessed both with respect to overall accuracy as well as to accuracy on each of the 11 channels and by type of affect.

Results

We first examined overall accuracy on the PONS among our three age groups (young adults, high functioning older adults, and low functioning older adults). High and low functioning older adults did not significantly differ in their overall accuracy ($p = .8$, $M_{accuracy} = .71$, $SD = .06$ for both). We therefore collapsed across executive function and conducted a t-test to compare overall performance by young and older adults. Results demonstrated that young adults outperformed older adults on the PONS ($p < .001$).

We examined these age differences by comparing older adults and young adults' accuracy on each of the 11 channels using a repeated-measures ANOVA. We found a main effect of channel type, $F(10, 780) = 45.06$, $p < .001$, a main effect of age, $F(1, 78) = 27.93$, $p < .001$, and an age × channel interaction, $F(10, 780) = 2.28$, $p < .02$. Closer examination of each channel using one-way ANOVAs revealed that young adults performed significantly better than older adults on 7 of the 11 channels (for complete list of mean accuracies, STDs, and *p*s by age group, see Table 1; see Table 2 for complete list of mean accuracies). No age differences emerged on 4 channels: face only (young adults: $M_{accuracy} = .81$, $SD = .10$, older adults: $M_{accuracy} = .81$, $SD = .12$), face only with content-filtered speech (young adults: $M_{accuracy} = .70$, $SD = .10$, older adults: $M_{accuracy} = .65$, $SD =$

Table 2
Participant Profile of Nonverbal Sensitivity (PONS) Performance

	Older adults	Young adults
Overall PONS accuracy	.71 (.01)**	.77 (.01)
Body only	.67 (.02)*	.73 (.02)
Face only	.81 (.02)	.81 (.02)
Figure only	.71 (.02)**	.80 (.02)
Content-filtered speech	.64 (.02)	.65 (.03)
Randomly-spliced speech	.61 (.02)**	.69 (.02)
Body with content-filtered speech	.63 (.02)**	.75 (.02)
Body with randomly spliced speech	.68 (.02)	.70 (.02)
Face with content-filtered speech	.65 (.02)	.70 (.02)
Face with randomly-spliced speech	.82 (.02)**	.94 (.01)
Figure with content-filtered speech	.78 (.02)*	.83 (.02)
Figure with randomly-spliced speech	.84 (.02)**	.93 (.01)
Negative dominant	.83 (.01)	.85 (.01)
Negative submissive	.73 (.01)**	.80 (.01)
Positive dominant	.61 (.01)**	.7 (.02)
Positive submissive	.57 (.02)**	.7 (.01)

Note. Performance accuracy (as mean proportion correct) on the PONS by young adults and older adults. Data are presented for overall PONS accuracy, accuracy on each of the 11 channels of the PONS, and accuracy by affect and dominance. Standard error presented in parentheses. Age differences denoted where applicable.
* $p < .05$. ** $p < .005$.

.12), content-filtered speech (young adults: $M_{accuracy} = .65$, $SD = .15$, older adults: $M_{accuracy} = .64$, $SD = .14$), and body only with randomly spliced speech (young adults: $M_{accuracy} = .70$, $SD = .14$, older adults: $M_{accuracy} = .68$, $SD = .12$).

Accuracy for Discriminating Between Positive and Negative Emotions

To better understand older adults' performance on the face only trials, we examined their accuracy on trials where they had to determine whether the target was conveying positive or negative information (e.g., they made a forced choice response between a positive dominant or negative dominant item). These data were entered into a 2 (affect: positive or negative) × 2 (age: young or older adult) ANOVA. Results revealed a trend toward a main effect of affect, $F(1, 79) = 3.56$, $p = .06$, but no effect of age, $F(1, 79) = 2.85$, $p = .1$ and no interaction ($F < 1$). Although both young and older adults were slightly better at identifying the emotion when faces were conveying positive (young adults: $M_{positive} = .89$, $SD = .17$, older adults: .94 $SD = .13$), compared with negative (young adults: $M_{negative} = .83$, $SD = .22$, older adults: .89 $SD = .19$), information, *t*-tests showed that this effect was not significant for either age group ($p > .1$ for both).

Accuracy in Discriminating Emotions From Submissive or Dominant Faces

Finally, we examined the effect of age on correctly recognizing behaviors that varied in affect and dominance. Again, no accuracy differences emerged between high and low functioning older adults, so we collapsed across executive function. We then conducted a 2 (affect: positive or negative) × 2 (dominance: dominant or submissive) × 2 (age: young adults or older adults) ANOVA using mean proportion correct scores. Results revealed a main effect of affect, $F(1, 78) = 215.06$, $p < .001$, dominance, $F(1, 78) = 28.35$, $p < .001$, and age, $F(1, 78) = 43.18$, $p < .001$. We also found an Affect × Age interaction, $F(1, 78) = 9.41$, $p < .005$, a Dominance × Age interaction, $F(1, 78) = 7.92$, $p < .01$, and a Valence × Dominance interaction, $F(1, 78) = 6.92$, $p = .01$, but no three-way interaction ($F < 1$).

Post-hoc *t*-tests demonstrated that the age × affect interaction emerged because although both young and older adults were more accurate at judging negative dominant compared with negative submissive clips ($p < .001$ for all), young adults' accuracy did not differ when evaluating positive dominant or positive submissive clips, whereas older adults' accuracy did (positive dominant > positive submissive clips; $p < .02$). In addition, we conducted post hoc *t*-tests to investigate the effect of age, and found that young adults were more accurate than older adults at judging all clips ($p < .001$), with the only exception being the negative dominance clips, where no age differences emerged ($p = .4$). Post-hoc *t*-tests also demonstrated that the main effect of affect emerged because both young adults and older adults were more accurate when judging negative affect compared with positive affect regardless of the level of dominance displayed in the clips ($p < .001$ for all). Finally, the effect of dominance emerged because both young adults and older adults were more accurate when judging dominant than submissive negative affect clips ($p < .02$ for all).

Discussion

Three main findings emerged from this experiment. First, no age differences emerged for decoding global emotional information from dynamic images of faces. Specifically, older adults performed as well as young adults when evaluating dynamic facial cues, regardless of whether the face was conveying positive or negative information. Second, executive function decline did not affect older adults' ability to evaluate nonverbal information accurately for any dynamic affective information. Finally, both young and older adults were more accurate in judging clips that conveyed negative, compared with positive, emotions.

General Discussion

These results suggest that older adults do not have emotion recognition deficits when evaluating global emotions from dynamic images of faces. However, older adults do have emotion recognition deficits in evaluating discrete negative emotions from static images of faces. Further, these deficits are exacerbated by age-related cognitive decline, but only for anger recognition. That is, low functioning older adults are notably impaired relative to high functioning older adults in discerning anger from static images of faces. Experiment 2 demonstrated that executive function decline did not affect older adults' ability to accurately categorize global emotions from dynamic facial cues. Together these results suggest that age-related deficits in emotion recognition may not be as pervasive as previously believed.

The results of Experiment 1 demonstrated that older adults experienced deficits in evaluating discrete negative emotions from static images of the face. Furthermore, these deficits were exacerbated by age-related cognitive decline. This finding is unsurprising given that emerging neuroimaging research has found that identifying anger engages the same areas of the frontal lobe that support general cognitive functioning (Adolphs, 2002; Blair, Morris, Frith, Perrett, & Dolan, 1999; Blair & Curran, 1999). However, it is puzzling that cognitive decline was unrelated to older adults' emotion recognition deficits for other emotions.

An alternative possibility for these deficits is that older adults may pay less attention to images portraying negative emotions and therefore be less accurate in decoding them. Indeed, numerous studies have shown that older adults avoid looking at negative, but not positive, facial expressions (Isaacowitz et al., 2006; Mather & Carstensen, 2003). Thus, older adults may not attend to negative images enough to decode the nuances of discrete negative emotions. This explanation might explain why older adults were impaired in decoding discrete negative emotions, but not global emotions. However, this explanation does not clarify why executive function decline only affected older adults' recognition of anger. An alternate explanation may reside in how aging affects the brain structures underlying emotion recognition. Emerging research suggests that the orbitofrontal cortex (OFC) may play a central role in recognizing the emotion anger from facial expressions (Blair & Curran, 1999; Sprengelmeyer et al., 1998). Of importance, it has been widely demonstrated that the OFC is particularly sensitive to age-related cognitive decline (e.g., Raz et al., 1997; Salat et al., 2004). Thus, our finding in Experiment 1 that executive function decline exacerbated emotion recognition deficits for anger may have reflected age-related changes in OFC, but future research should investigate this point.

It is interesting to note that older adults were relatively more accurate in evaluating global negative, compared with positive, social cues. This finding suggests that older adults may decode dynamic negative information better than positive information. However, this finding does not suggest that older adults favor negative over positive information, simply that they are more accurate in decoding affect from negative, compared with positive, social cues. However, an important limitation of Experiment 2 was that we only focused on global emotion recognition deficits. Future research should investigate whether older adults are impaired on recognizing discrete negative emotions from dynamic images of faces.

One puzzling result from Experiment 2 was that older adults performed as well as young adults on judging dynamic clips that conveyed negative dominance, but underperformed on judging dynamic clips that conveyed both negative affect and submissiveness. One possible explanation for this result is that the negative dominance clips may have been more arousing than the negative submissive clips and therefore easier to interpret. Future research should examine whether the negative dominance clips may have been more arousing than the other clips and therefore more salient to perceivers.

Together these results suggest that older adults can accurately evaluate global emotions from dynamic cues, even when they are only presented with that cue for a brief period of time. However, they are impaired in evaluating discrete negative emotions from static facial cues, and this deficit is exacerbated by age-related cognitive decline.

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