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Interpretive bias of ambiguous facial expressions in older adults with depressive symptoms

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Abstract: Cognitive theories of emotional disorders indicate that biases in cognitive processes, such as attention, memory, and interpretation, are common factors that indicate vulnerability to these disorders, although their form varies according to the type of disorder. However, most of the studies have focused on adolescence and adulthood. It is still uncertain whether cognitive biases are risk factors for late-life depression. The present study sought to explore the role of interpretive bias in older adults with depressive symptoms and whether this effect is independent of basic cognitive abilities. Therefore, 18 older adults with depressive symptoms and 21 healthy controls were compared with an ambiguous facial expression identification task, a Mini Mental Status Examination, a Trail Making Test A and B, and a Word Fluency Test. Findings revealed that the depressive group was more likely to identify more ambiguous happy–sad facial expressions as indicative of sadness than were the healthy controls, but the two groups showed no significant differences in the cognitive test scores. These results suggest that interpretive bias indicates vulnerability to late-life depression, but basic cognitive abilities may have no influence in this context.

Keywords: aging; depressive symptoms; facial expression; interpretive bias

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Our thoughts regarding what is happening around us are colored by the way we feel. Specifically, the interpretation of ambiguous information is affected by our emotions. A depressed person is more likely to regard another's slight smile as a hostile sneer, rather than a genuine positive emotion. Therefore, several researchers in the field of depression have been interested in the interpretation of ambiguous information. Cognitive models of depression posit that an information-processing bias affects the onset, maintenance, and recurrence of depression (Beck, 1976). The interpretive bias is an important information-processing bias that refers to the tendency to use information to interpret ambiguous stimuli, scenarios, and events that are affected by the current focus or concern of the individual (MacLeod, 1990). The current concerns of depressed people are sadness, loss, failure, rejection, and other negative information. Therefore, depressed individuals may interpret ambiguous information negatively and this interpretive bias may play an important role in the development and maintenance of depression (Mathews & MacLeod, 2005). Although researchers believe that an information-processing bias may be observed in depression, it is still unclear whether the interpretive bias causes vulnerability to depression.

Ample empirical evidence from various self-report measures has confirmed close connections between depression and interpretive bias (Gupta & Kar, 2008; Krantz &

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Hammen, 1979; Pury, 2002). These tests presented participants with many ambiguous scenarios (e.g., "You are suddenly awakened by a loud sound in the middle of the night."), followed by either a negative interpretation (e.g., "A person was robbed.") or a positive interpretation (e.g., "A person celebrated a victory."). The participants were asked to select the answers that best fit the scenarios. The results indicated that the depressed participants chose the negative interpretations more often than did the healthy controls (Butler & Mathews, 1983). In addition, this trend was observed not only in the depressed participants, but also in participants exhibiting high scores on the Costello-Comrey Depression Scale (Cane & Gotlib, 1985). Although the results of these studies were consistent with the assumption that interpretive bias and depression are closely related, many researchers have questioned the evidence from self-report methods that could be affected by response bias (Lawson, MacLeod, & Hammond, 2002). A response bias reflects an elevated tendency to emit or endorse negatively toned response options by depressed people (Lawson & MacLeod, 1999). Compared with interpretive bias, response bias is only a reporting bias. For example, depressed populations may process both negative and positive interpretations of ambiguous stimuli, but report negative interpretations more frequently than healthy controls. Furthermore, self-report measures are affected by subjective experience, which may be skewed because of anchoring and overestimation (Rude, Wenzlaff, Gibbs, Vane, & Whitney, 2002). Mogg, Bradbury, and Bradley (2006) simultaneously used two cognitive tasks (e.g., a homophone task and a text comprehension task) to investigate whether depressed participants had an interpretive bias. The results showed that depressed participants made more negative interpretations on the homophone task than did the healthy controls, but there were no differences in their interpretive bias on the text comprehension task. Therefore, they suggested that depressed populations may exhibit only a response bias, not an interpretive bias.

To overcome the response bias limitations of self-report measures, a priming methodology was developed. Based on this methodology, participants were presented with ambiguous materials as primes (e.g., *loom), each permitting either a negative or positive interpretation (e.g., gloom or bloom), and then were examined regarding how this promoted the processing of the target materials (e.g., gloom or bloom). Researchers could infer clinical subjects' interpretive bias by exploring the degree to which these prime stimuli facilitated the processing of subsequent negative targets compared with the control subjects (Richards & French, 1992). Depression-linked interpretive bias was examined by Lawson and MacLeod (1999) to understand whether depressive participants displayed exaggerated priming effects on targets that were associated with more negative meanings of the ambiguous prime stimuli than did the healthy controls. However, the pattern of priming effects obtained in their study contained no evidence to support the existence of an interpretive bias in the depressed population. Furthermore, a negative interpretive bias still did not exist in depressive participants after the negative mood induction (Bisson & Sears, 2007).

However, Lawson et al. (2002) thought that the failure in detecting an interpretive bias by the priming method could be due to the use of latency measures (e.g., reaction times) to assess cognitive processing in the depressed populations. Specifically, higher levels of depressive symptoms are related to not only the slowing of reaction times to execute voluntary responses, but also the increased variability of such response latencies. Therefore, reaction times are not sensitive indices of interpretive bias in depressed populations. To overcome the limitation of reaction times in the priming method, Lawson et al. adopted physiological indices such as the magnitude of the human blink reflex, which was augmented when elicited during negative rather than neutral imagery. In their study, the blink magnitudes displayed by the depressed populations were substantially larger than those of the healthy controls, particularly when the targets were evoked by ambiguous stimuli rather than by unambiguous neutral stimuli. In other words, in depressed populations, the blink reaction elicited by ambiguous words is similar to that elicited by negative words, while the blink reflex magnitudes in reaction to ambiguous words is far smaller than those in reaction to negative words in healthy controls. Thus, these results indicate the presence of an interpretive bias in depressed populations.

However, there are several limitations in the use of ambiguous words, sentences, scenarios, and events as experimental material to examine interpretive bias in depressed populations. Due to the low levels of emotional load, such stimuli have poor sensitivity and ecological validity. Therefore, an increasing number of researchers have recently adopted facial expressions as experiment stimuli (e.g., Beevers, Wells, Ellis, & Fischer, 2009; Jusyte & Schönenberg, 2014). As compared with the material used in the above studies, facial expressions have many advantages. First, facial expressions are not affected by culture and people of different races tend to have similar interpretations

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of basic facial expressions (Ekman & Friesen, 1971). Second, facial expressions are important interpersonal stimuli, and they play a very important role in social interactions (Mayer, DiPaolo, & Salovey, 1990). For example, facial expressions convey approximately 60% of information between social partners (Burgoon, 1985). Third, interpersonal theories of depression indicate that depressed populations tend to interact with others in a way that elicits rejection, which exacerbates their risk for future depression (Hames, Hagan, & Joiner, 2013). Facial expressions are closely related to the social evaluations of approval or disapproval of the situations (Gilboa-Schechtman, Foa, Vaknin, Marom, & Hermesh, 2008), while the main features of depressed populations are fear of rejection, social withdrawal, and a strong sense of loneliness. Fourth, the essence of social-emotional function involves appropriate interpretation of others' facial expressions and responding to them appropriately (Bourke, Douglas, & Porter, 2010). In addition, as people often try to control the expression of emotion in everyday social communication, mild or ambiguous facial expressions are common. As these ambiguous social signals are relatively difficult to perceive and interpret, their interpretation may be a more sensitive index of interpretive bias as compared with unambiguous facial expressions.

Previous studies that used facial expressions as experimental material have provided evidence supporting the presence of interpretive bias in the depressed populations. For example, Beevers et al. (2009) presented a series of human facial expressions (e.g., happiness, sadness, anger, fear, and a morphed mixture of two facial expressions) to dysphoric and nondysphoric college students. They found that the dysphoric and nondysphoric participants identified prototypical facial expressions similarly, but the former were more likely to interpret ambiguous happy–sad mixed expressions as sadness. Using a similar methodology, Gilboa-Schechtman et al. (2008) presented depressed participants and healthy controls with facial stimuli that were morphed from neutral facial expressions to angry or sad expressions. They found that depressed participants were more likely to interpret less intense angry and sad expressions as negative emotions than the healthy controls. Similarly, Joormann and Gotlib (2006) found that when compared with healthy controls, patients with severe depression required greater intensity of expressions to identify happy emotions, but required less intensity of expressions to identify sadness compared with anger.

Indeed, there is a lack of consensus on whether the interpretive bias in depressed populations is affected by basic cognitive processes. Previous studies have found that cognitive factors (e.g., memory deficits, spatial processing deficits, and visual perceptual deficits) may account for impaired processing of facial expressions in depressed populations (Asthana, Mandal, Khurana, & Haque-Nizamie, 1998; Gilboa-Schechtman, Erhard-Weiss, & Jeczemien, 2002; Suslow et al., 2004). However, other researchers thought that an inability to interpret facial expressions was not explained by basic cognitive impairment, even when rigorous neuropsychology tests were used (Diehl-Schmid et al., 2007).

Geriatric depression is a highly prevalent emotional disorder and a risk factor for the onset of severe illnesses (e.g., Alzheimer's), and can lead to physical, cognitive, and social dysfunction (Alexopoulos, 2005). Thus, not only does it cause considerable suffering for patients and their relatives, but it also increases significantly the mortality rate, and causes massive economic burden. Even minor depression (e.g., subthreshold depression) presents a series of negative consequences. For instance, it increases the number of medical and mental health service demands, promotes social dysfunction and disability, accelerates suffering, decreases the quality of life, and is a factor that makes the individual vulnerable to recurrent major depression (Chopra et al., 2005; Vahia et al., 2010). Although previous studies on adolescents and adults showed potentially close correlations between depression and interpretive bias, its presence in older adults is still uncertain because of the differences in the presentation of depression and processing of emotional information between these groups and older adults (Bucks, Garner, Tarrant, Bradley, & Mogg, 2008; Carstensen, Isaacowitz, & Charles, 1999). First, compared with depressed adolescents and adults, depressed older adults reported more insomnia, lethargy, and lack of appetite relative to depressed mood (National Institutes of Health, 1991). Second, according to Carstensen's socio-emotional selectivity theory, older adults showed the positivity effect in the processing of emotional information (e.g., focusing attention and memory on positively valenced materials rather than negatively valenced materials) compared with their younger counterparts (Carstensen et al., 1999; Carstensen & Mikels, 2005).

In the current study, we assessed interpretive bias in older adults with depressive symptoms by using an objective ambiguous facial expression identification task rather than self-report questionnaires, which not only could reduce the negative influence of response bias through experimental manipulation (e.g., random stimulus presentation and

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counterbalanced response assignment), but also help to combine cognitive theories and interpersonal ones of depression into an integrative model of depression. We hypothesized that compared with healthy controls older adults with depressive symptoms would exhibit a negative interpretive bias, while the interpretive bias was independent of basic cognitive functions.

Method

Participants

All participants were recruited via the participants' database from our previous study, which included 61 older adults with depressive symptoms and 245 without depressive symptoms (Dai, Peng, & Li, 2014). First, 18 subjects (12 women) were selected at random from among those exhibiting depressive symptoms. We then began compiling a healthy control sample by randomly selecting subjects from the pool of 245 without depressive symptoms, on the basis of their participant number using the select cases command in SPSS software, and excluding those with significant differences in sex, age, or educational level with the depressive symptoms group. We continued the process until we had a control group of 21 healthy participants (15 women) which matched the depressive symptoms group in terms of demographic variables (sex, age, and educational level). All subjects had normal or corrected-to-normal vision, and provided written informed consent in keeping with the procedures and protocols recognized by the institutional review board of the Institute of Psychology, Chinese Academy of Sciences. Each participant received a gift for their participation.

Stimuli: Morphed facial expressions

The prototype happy and sad expressions used in the present experiment were selected from the Chinese Facial Affective Picture System, which includes 870 facial stimuli depicting a series of emotions (including happy, sad, angry, fearful, disgusted, surprised, and calm; Gong, Huang, Wang, & Luo, 2011). Pictures of five male and five female models with happy and sad facial expressions were used in the present study. Each face was used to create a series of happy–sad ambiguous facial expressions using free trial morphing software (Morpheus v. 1.95) with 10% increments, according to image-manipulation techniques used in previous studies that investigated the recognition of facial expressions (e.g., Beevers et al., 2009; Bucks et al., 2008). The resulting happy–sad continuum consisted of a face expressing 90% happy and 10% sad, a face expressing 80% happy and 20% sad, a face expressing 70% happy and 30% sad, and so on, up to a face expressing 10% happy and 90% sad (see Figure 1).

Procedure

The experiment was controlled using the E-prime software installed on Lenovo desktop computers. Every participant was tested individually. At the beginning of the experiment, brief instructions were presented to the participants on the computer screen, in large print, which were also clarified orally by the experimenters to ensure that they understood the demands of the experiment. Then the participants viewed one image at a time and indicated the emotion expressed in the image. Each trial began with the presentation of a central white fixation cross for 500 ms. Next, the happy–sad morphed stimulus (15 cm high and 12 cm wide) was presented on the screen until the participant responded. Then, the participants were asked to select one of two labels ("happy" or "sad") as accurately and quickly as possible. The intertrial interval was 2500 ms. Response labels were placed on the keyboard and the positions of the happy/sad response labels were counterbalanced among the participants. All participants completed three blocks of 120 trials each for a total

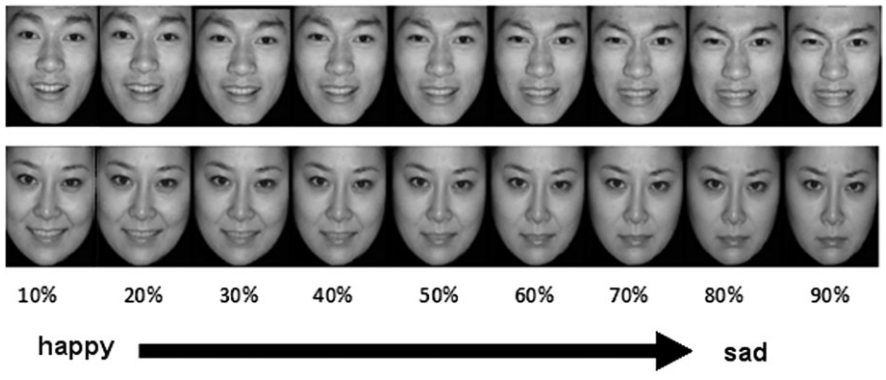

Figure 1. Examples of facial expressions morphed along the happy–sad continuum. The percentages indicate the mean percent of the sad prototype. Thus, 10% = 90% happy and 10% sad, 50% = 50% happy and 50% sad, 90% = 10% happy and 90% sad.

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of 360 trials. Each block included 60 trials total in the 10–30% sad and 70–90% sad ranges, with 10 trials in each 10-percentile range (10%, 20%, 30%, 70%, 80%, and 90%), plus 60 trials in the intermediate 40–60% sad ranges, with 20 trials in each 10-percentile range (40%, 50%, and 60%). The reason for this arrangement with double the number of trials in the intermediate 10-percentile ranges is because they are more ambiguous than the others. The task duration was approximately 30 min. Following the experiment, participants also completed neuropsychological assessments (Mini Mental Status Examination [MMSE], Trail Making Test [TMT], and Word Fluency Test [WFT]).

Instruments

The Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977) is a self-rating scale consisting of 20 items to assess the presence and severity of depressive symptoms. The frequency of occurrence of each symptom during the past week is rated on a 4-point Likert-type scale, and the total scores range from 0 to 60. The standard cutoff for depressive symptoms is a score of 16 or greater. The CES-D has been shown to possess excellent psychometric properties with older adults (Lewinsohn, Seeley, Roberts, & Allen, 1997). In the current study, the CES-D was used to assess the depressive symptoms.

The MMSE is a scale consisting of 19 questions with scores ranging from 0 to 30, where higher scores are indicative of better cognitive status. The scale was used to assess several cognitive domains, including orientation to time, orientation to place, registration of three words, calculation, spelling backwards, naming, repeating a phrase, following commands, sentence construction, and copying a figure. The MMSE has been validated in the Chinese population (Xu et al., 2003) and the Chinese version of the MMSE was used to assess the participants' cognitive abilities in this study.

The TMT comprises two parts, A and B (the Chinese version, Lu & Bigler, 2002). In Part A, participants were asked to connect a series of consecutively numbered (Arabic) circles, which involves skills such as visual scanning, number recognition, numeric sequencing, and motor speed. In Part B, participants were required to connect a series of consecutively numbered (Arabic and Chinese) circles alternately. This subtest assesses mental flexibility in managing more than one stimulus at a time and in shifting the course of an activity in progress. The time difference (B − A) was used to evaluate executive function, including visual search, visuospatial sorting, and cognitive set shifting. For both Parts A and B, the score is the total time (in seconds) taken to complete the task.

The WFT (the Chinese version; Tong, Yip, Lee, & Li, 2002) was used to measure participants' semantic memory. All participants took the semantic WFT using "food" and "animal" as the defined categories. Participants were required to produce as many words as possible within 1 min (by stopwatch) after receiving the instructions. If participants stopped before the assigned time they were encouraged to name more words. Each participant was first required to produce food names and then animal names. The score was the average number of food and animal names recollected in 1 min, where a higher number of words indicated better semantic memory.

Data analysis

First, the differences in cognitive measures and depressive symptoms between the control group and the depressive symptoms group were tested by two independent samples *t*-tests. We then computed the probability and reaction time for identifying sad expressions for each of the nine morphed faces (e.g., probability and reaction time in identifying a sad face at Morph Increment [MI] 4 on the happy–sad continuum). Probability estimates were obtained for each MI, for each participant, from 0 to 1. Reaction time data greater than two standard deviations from the mean were treated as outliers and were excluded from subsequent analyses. A two-way mixed-design repeated measures ANOVA was conducted, with the MI being the within-subjects factor and the group (depressive symptoms group and control group) the between-subjects factor. Multiple comparisons were performed by employing Bonferroni corrections for all post hoc tests.

Results

Participants' characteristics and questionnaire data

Table 1 presents the demographic characteristics of the two groups (participants with depressive symptoms and healthy controls). The two groups did not differ significantly in terms of sex distribution, $\chi^2(1) = 0.10$, $p > .05$. In addition, the two groups did not differ significantly in terms of age, $t(37) = 1.91$, $p > .05$, or educational level, $t(36) = 0.36$, $p > .05$. The above analysis suggested that the control group was individually matched to the depressive symptoms group on the demographic variables. The scores of the CES-D in

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Table 1
Demographics and Questionnaire Scores of Participants (M ± SD)

	Control group ($n = 21$)	Depressive symptoms group ($n = 18$)	t/χ^2	p-Value
Sex	15 female	12 female	0.10	.75
Age (years)	71.5 ± 4.3	67.7 ± 7.5	1.91	.07
Educational level (years)	11.5 ± 3.7	11.9 ± 3.4	0.36	.73
Center for Epidemiologic Studies Depression Scale	3.19 ± 2.18	21.39 ± 4.83	14.75	.001***
Mini Mental State Examination	28.81 ± 1.33	27.56 ± 2.48	1.92	.07
TMT-A	40.35 ± 15.41	40.15 ± 17.64	0.04	.97
TMT-B	76.23 ± 50.81	80.95 ± 39.41	0.32	.75
(TMT-B) − (TMT-A)	35.88 ± 40.98	40.80 ± 28.75	0.43	.67
Word Fluency Test	23.86 ± 6.77	20.22 ± 4.15	1.98	.06

Note. TMT = Trail Making Test.
***$p < .001$.

Table 2
Proportion of Judging Sadness on the Morph Increments of the Two Groups (M/SD, %)

	Morph increment								
Group	1	2	3	4	5	6	7	8	9
Control group	1.11 (1.92)	1.59 (2.71)	6.03 (7.72)	18.73 (10.89)	37.94 (15.15)	66.11 (12.78)	84.60 (10.08)	92.54 (7.37)	94.92 (5.12)
Depressive symptoms group	2.50 (2.43)	5.00 (8.80)	11.67 (12.06)	28.15 (12.30)	51.48 (11.24)	76.02 (10.31)	87.78 (8.24)	93.89 (5.75)	94.81 (4.60)

the depressive symptoms group were significantly higher than those in the healthy control group, $t(38) = 14.75$, $p < .001$. Finally, the two groups did not differ significantly for performance on the MMSE, TMT, and WFT (see Table 1).

Proportion of judging the MIs as sad

To examine the presence of group differences in their responses to emotional stimuli, we first calculated the proportion of judging the MIs as sad in the two groups (see Table 2 and Figure 2). Subsequently, a 2 (group: control and depressive symptoms) × 9 (MI: 1–9) two-factor mixed design ANOVA was performed, which indicated the significance of the main effect of MI, $F(8, 296) = 1106.73$, $p < .001$, and the interaction of Group × MI, $F(8, 296) = 3.86$, $p < .01$. The simple effects analysis indicated that the proportion of judging the increments as sad by the two groups differed significantly at MI4, $F(1, 37) = 6.43$, $p < .05$, $d = .42$; MI5, $F(1, 37) = 9.76$, $p < .005$, $d = .52$; and MI6, $F(1, 37) = 6.94$, $p < .05$, $d = .44$. Participants in the depressive symptoms group identified more expressions on these three MIs as sad than did the control group. On the other levels, however, there were no significant differences between these two groups: MI1, $F(1, 37) = 3.97$, $p > .05$; MI2, $F(1, 37) = 2.85$, $p > .05$; MI3, $F(1, 37) = 3.11$, $p > .05$; MI7, $F(1, 37) = 1.13$, $p > .05$; MI8, $F(1, 37) = 0.40$, $p > .05$; and MI9, $F(1, 37) = 0$, $p > .05$. In sum, the participants with depressive symptoms were more likely to identify sadness in the three most ambiguous stimuli than were the healthy controls.

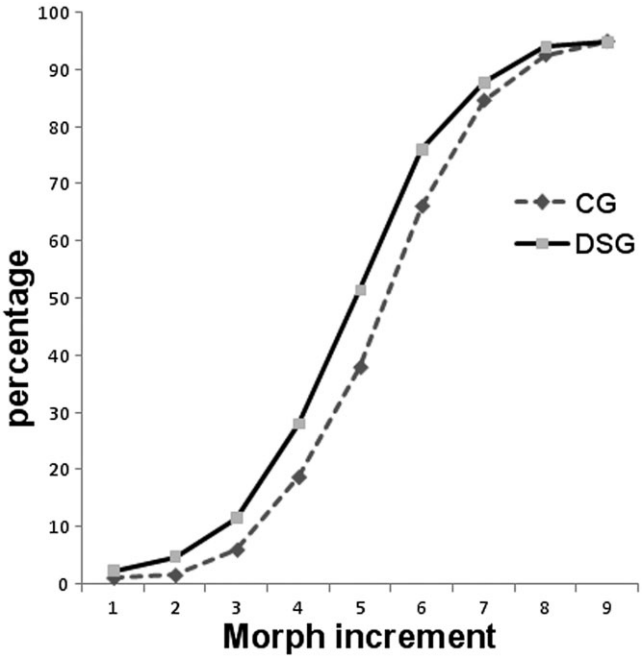

Figure 2. Proportion of judging the morph increments as sad in the two groups. CG = control group; DSG = depressive symptoms group.

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Table 3
Reaction Times of the Two Groups on the Images of the Morph Increments (M/SD, ms)

	1	2	3	4	5	6	7	8	9
Control group	864 (28)	896 (26)	938 (24)	994 (25)	1078 (21)	1106 (28)	1059 (27)	1011 (32)	998 (33)
Depressive symptoms group	898 (30)	925 (28)	959 (26)	1018 (27)	1067 (23)	1029 (30)	994 (29)	956 (35)	930 (35)

Reaction time of the two groups on the MIs

The average reaction time of the two groups on the MIs is presented in Table 3. In order to examine whether there were group differences in the reaction time of their responses to the emotional stimuli, a 2 (group: control and depressive symptoms) × 9 (MI: 1–9) mixed design ANOVA was used. The results showed a significant main effect for MI, $F(8, 296) = 36.51$, $p < .001$. The more ambiguous were the stimuli, the longer the reaction times. In addition, a significant effect was observed for the Group × MI interaction, $F(8, 296) = 4.65$, $p < .01$. However, the simple effect analysis revealed that the difference on MI6 was only marginally significant, $F(1, 37) = 3.49$, $p = .07$. In addition, there were no significant differences for other increments, $F(1, 37) = 0.12–2.64$, $p = .11–.73$. Thus, there were no differences in the reaction times between the participants with depressive symptoms and the healthy controls in their response to ambiguous facial expressions.

Discussion

The present study aimed to examine whether older adults with depressive symptoms exhibited a negative interpretive bias for ambiguous facial expressions. We hypothesized that a negative interpretive bias should be reflected in the facial expressions with higher ambiguity. Similar to the results from the study on dysphoric youth (Beevers et al., 2009), no group differences were observed for the facial expressions with lower ambiguity (e.g., 10–30% and 70–90% MIs of happy–sad mixed emotions). Thus, depressive symptoms in older adults do not appear to impact the identification of less ambiguous facial expressions. However, group differences were observed for the facial expressions with higher ambiguity (e.g., 40–60% MIs of happy–sad mixed emotions). In other words, older adults with depressive symptoms were more likely to identify sadness in the three most ambiguous facial expressions than the healthy controls. These results provided evidence of an interpretive bias in older adults with depressive symptoms. Contrary to this, Carstensen's socioemotional selectivity theory states that healthy older adults exhibited positivity preferences for emotional information (e.g., attention and memory positively valenced rather than negatively valenced stimuli; Carstensen et al., 1999; Murphy & Isaacowitz, 2008). However, these traits may not extend to older adults with depressive symptoms. These findings were consistent with the cognitive theories of depression (Beck, 1976) which suggest that the heightened tendency to interpret ambiguity in a negative manner might play an important role in the individual's depressive vulnerability.

The results of the current study may also provide insight into interpersonal theories of depression, which indicate that depressive patients have a tendency to communicate with others in a way that elicits rejection and that they have many interpersonal deficits (Hames et al., 2013). Older adults with depressive symptoms tend to negatively interpret ambiguous happy–sad emotions from their social partners, which not only reinforces their negative feedback-seeking behaviors to increase the negative affect, but also makes their social partners reluctant to express positive emotions and makes them consider communication with the depressed person as tiresome. Furthermore, such negative feedback seeking makes them perceive stimuli more negatively and increase their feeling of rejection by their communication environment. In sum, the results from the current study provide strong evidence linking the cognitive theory of depression with the interpersonal theory of depression and supporting a proposal for an integrative model of depression.

Previous studies suggested that depressive individuals showed a negative interpretive bias in self-report measures (Gupta & Kar, 2008; Krantz & Hammen, 1979; Pury, 2002). However, this negative interpretive bias was not observed while using priming methods, because reaction time is not a sensitive index (Lawson & MacLeod, 1999). The view was supported by the results of the current study, which revealed no group differences in the reaction time during identification of happy–sad mixed emotions in the MIs with reference to older adults with depressive symptoms and healthy controls. Similar to other psychiatric conditions, depressive symptoms may produce slow and variable motor responses that interfere with the manual reaction time data (Lawson et al., 2002). However, when compared with previous methods, the current study has some advantages. First,

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instead of ambiguous words, sentences, scenarios, and events, happy–sad ambiguous facial expressions have been shown to possess good sensitivity and ecological validity because they are important interpersonal stimuli and are closely associated with depressive concerns. In particular, the facial expressions with higher ambiguity are more sensitive tools by which to assess interpretive bias in older adults. For instance, the effect size of MI5 (50–50% happy–sad) was the maximum, indicating that the facial expressions with higher ambiguity are the more sensitive tools by which to assess interpretive bias. Second, when compared with self-report measures, experiment tasks are not vulnerable to subjective factors. Third, compared with the priming technique, this task does not rely on the reaction time index to infer interpretive bias.

Previous studies have suggested that deficits in visual perceptual processing, spatial processing, and memory would account for impaired emotion recognition in depressed people, people with schizophrenia, social phobia, and other clinical populations (Asthana et al., 1998; Bediou et al., 2005; Gilboa-Schechtman et al., 2002; Horley, Williams, Gonsalvez, & Gordon, 2004; Suslow et al., 2004). However, the current study found no group differences in the basic cognitive functions in the older adults with depressive symptoms compared with the healthy controls. This inconsistency across the findings may be caused by two reasons. First, depressive symptoms in our participants were so minor that they did not qualify for a standard diagnosis of clinical depression. Therefore, although there are cognitive impairments in major depressive disorder, these symptoms may have little impact on the participants' cognitive performance at the early stage. Thus, basic memory, spatial abilities, and executive function may be relatively preserved in our sample. This supposition may be supported by the current results that our two groups only identified sadness differently on the facial expressions with higher ambiguity, which was not observed in the cases of less ambiguous stimuli. However, in some studies, depressed populations and other clinical populations have identified clear facial expressions differently from the healthy controls (Milders, Bell, Platt, Serrano, & Runcie, 2010). Second, there are remarkable differences between our neuropsychological tests and those employed in other studies. For example, their tests usually used faces that possessed more social attributes that were closely correlated to the clinical populations as materials to assess cognitive abilities. However, our tests used neutral material (e.g., space and number) as stimuli to assess cognitive functions.

There are several limitations of this study to discuss. First, the participants were a convenience sample recruited from high-quality communities, which limited the generalizability of our findings to less-educated older populations. Second, we selected older adults with depressive symptoms according to a self-report scale (CES-D). Although persons with clinical depression were excluded by oral examination rather than a clinical diagnosis system (e.g., DSM-IV), it is unclear whether our depressive symptoms group included any clinically depressed patients. Third, previous studies have indicated a negative interpretive bias in anxiety disorder or social phobia (Jusyte & Schönenberg, 2014; Yoon & Zinbarg, 2008). It is possible that participants in our sample would have been diagnosed with anxiety disorders or may have a higher tendency to worry. These unmeasured factors could have interfered with the findings, although the happy–sad mixed expressions selected in the current study were most suitable for depressive concerns, as compared with the happy–anger mixed expressions appropriate for phobia concerns (McNally & Foa, 1987). Finally, although our sample size was moderate, a larger sample could have provided more statistical power.

In summary, despite the above limitations, the current study offers strong evidence for the presence of a negative interpretive bias for ambiguous facial expressions amongst older adults with depressive symptoms. To our knowledge, this is the first study to examine a negative interpretive bias in older adults. The current results may have important clinical implications. Geriatric depression has many detrimental consequences (e.g., suffering, economic burden, disability, and mortality; Alexopoulos, 2005). Therefore, it is necessary to explore more sensitive instruments to screen geriatric depression at an early stage. According to the depressive spectrum, depressive symptoms are milder than clinical depression, but indicate that the individual may be vulnerable to clinical depression (Royall, 2004). The results of the present study indicated that the performance of older adults with depressive symptoms on the interpretive bias task involving facial expressions with higher ambiguity differed from healthy controls. This result could be adapted to develop a highly sensitive tool to assess depressotypic cognitive bias, which is a vulnerability to depressive symptoms. In addition, previous studies have suggested that interpretive bias modification was used as a "cognitive vaccine" for depressive moods, which brought about greater improvements in negative cognitions (e.g., interpretive bias and depressogenic beliefs) or depressive symptoms in young adults (e.g., Blackwell & Holmes, 2010; Micco, Henin, &

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Hirshfeld-Becker, 2014). Thus, future work should consider exploring whether an interpretive bias modification paradigm (e.g., introducing positive feedback into facial expressions with higher ambiguity) helps reduce negative interpretive bias and depressive symptoms in older adults, which would ultimately inform treatment development of geriatric depression.

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