# UNBINDING OF CONTEXTUAL INFORMATION: AGE DIFFERENCES AND CULTURAL EFFECTS

by

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## Abstract

Age and cultural effects on memory for complex pictures were examined under an unbinding condition. Young and older Canadians and Chinese were tested in Toronto and Beijing respectively. At encoding, participants viewed semantically congruent or incongruent pictures. At recognition, they were asked to recognize the objects and backgrounds of these pictures in isolation. The results revealed effects of both age and culture on recognition performance. Older adults recognized more objects than young adults, whereas Canadians were better than Chinese in background recognition. There was also a trend for Canadian older adults to recognize more objects and backgrounds than the other groups of participants. Age and cultural differences in memory under unbinding were possibly due to group differences in information binding during encoding. Finally, it was found that images from congruent pictures were better recognized than those from incongruent pictures, suggesting that semantic relatedness of information improves recognition under unbinding.

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Individual experiences and the social practices of one's culture can influence the development and use of cognitive processing (Nisbett, Peng, Choi, & Norenzayan, 2001). Cultural factors that may affect cognitive performance include differences in languages, learning styles, education systems, child-rearing practices, and other societal values (Hedden et al., 2002). Cross-cultural studies typically compare Western individuals (e.g., Americans and Canadians) with East Asians (e.g., Chinese, Koreans, and Japanese). Past research suggests that East Asians show a better performance on tasks that require context-oriented holistic processing, whereas Western individuals perform better on tasks that rely on feature-driven analytic processing (e.g., Nisbett & Miyamoto, 2005; Nisbett et al., 2001; Park, Nisbett, and Hedden, 1999).

Nisbett and colleagues (2001) suggest that differences between the social structure of Western and East Asian cultures contribute to cultural differences in cognitive processing. In East Asian societies, there is an emphasis on social relationships and group harmony. To facilitate social interactions, it is crucial for East Asians to attend to cues in the social environment and role relations within their social groups. It is suggested that this habit of processing might have transferred to attention to the environment in general, whereby East Asian individuals show a tendency to focus on the relations among surrounding objects and events. As a result, East Asians are comparatively more holistic in cognitive processing (Nisbett et al., 2001), and are more likely to pay attention to and process contextual information, as well as to group objects, events, and individuals according to their mutual relationships (Masuda et al., 2008). As a consequence of the tendency in context-oriented processing, East Asians may find it difficult to encode focal objects or information in isolation from their contexts (Masuda et al., 2008). In contrast, there are fewer social role constraints in Western than in East Asian societies, and Western individuals value autonomy and freedom (Nisbett et al., 2001). It is therefore suggested that Western individuals are more likely than East Asians to attend to focal objects and their value to the self. They are comparatively more analytic in cognitive processing, and have a tendency to observe and process properties of objects as a means to develop categories and rules that define the characteristics of the objects (Nisbett et al., 2001). Finally, Western individuals also tend to pay more attention to focal objects and information, and therefore are less affected by the change in contextual information.

**Cultural Differences in Attention and Memory**

A number of research studies have investigated cultural differences in cognitive processing, such as attention and memory, among young adults. It has been demonstrated that Japanese and American individuals perform differently on the framed-line test (Kitayama, Duffy, Kawamera, & Larsen, 2003). In this study, participants were shown a standard square frame with a vertical line in the center of the frame. The participants were then asked to reproduce the line in an empty square frame that was of the same or different size. In the absolute task, the participants were required to draw a line of the same length as that in the standard square frame. In the relative task, they were asked to draw a line with the same proportion to the size of the frame as in the standard diagram. Japanese were more accurate in the relative task whereas Americans were more accurate in the absolute task, which suggests that perception is influenced by culture: Japanese paid more attention to the context (i.e., the frame) whereas Americans tended to focus more on the focal object (i.e., the line). Kuhnen and colleagues (2001) also demonstrated that East Asians' perception is more influenced by contextual information than that of Western individuals. The researchers administered the embedded-figures test (EFT), in which participants were shown geometrical patterns that contained a number of embedded figures.

Participants were asked to detect as many target figures in each pattern as possible within 2 minutes. The results indicate that Malaysian and Russian participants detected fewer figures than participants in the United States and in Germany. The researchers speculated that the poorer performance among Malaysian and Russian participants was due to their field dependency in perception. In comparison to American and German participants, they were more attentive to the holistic layout of the patterns, making the detection of individual features challenging.

Chua, Boland, and Nisbett (2005) measured the eye movements of Chinese and American participants as they were looking at photographs that contained a focal object embedded in a background scene. American participants fixated sooner and longer on the focal objects, whereas their Chinese counterparts demonstrated a more balanced fixation towards the objects and the backgrounds. This is an indication that Chinese tend to pay more attention to background information than Western individuals. Masuda and Nisbett (2001) also investigated cultural differences in attention allocation during visual processing tasks. They showed animated video clips of underwater scenes to Japanese and American participants. Participants were asked to verbally describe the scenes and were subsequently tested for their recognition of the objects in the scenes. In comparison to American participants, Japanese participants provided more descriptions about the background scenes and the relations between the focal objects and the scenes. They also recognized more previously seen objects when they were presented with original backgrounds than with novel backgrounds during recognition. In contrast, Americans were not affected by the background scenes, and both their descriptions of the scenes and recognition of the objects were less affected by contextual changes.

Evans and colleagues conducted an eye-movement study using Chua et al. (2005)'s picture stimuli, in which they recorded participants' eye movements at both encoding and testing

(Evans, Rotello, Li, & Rayner, 2009). Contrary to the findings of Chua and her colleagues, Evans et al. did not find any cultural differences in fixation during encoding and testing. Moreover, Chinese participants' memory for objects was not more affected by the re-pairing of background scenes at testing than American participants. It should be noted, however, that Evans et al. tested their Chinese participants in the United States. Although they reported that the Chinese participants were born in either China or Taiwan, they did not mention the number of years they had been in the United States. Chinese participants in Chua et al.'s study, on the other hand, completed their undergraduate studies in China. Disparity between these two studies may therefore be due to differences in participants' levels of exposure to Western culture.

Neuroimaging studies have also provided converging evidence on cultural differences in cognitive processing. Jenkins, Yang, Goh, Hong, and Park (2010) showed pictures of objects against congruent and incongruent backgrounds to their Chinese and American participants. Using functional magnetic resonance imaging (fMRI), the researchers employed an fMR-Adaptation (fMR-A) paradigm, in which the attenuation of the blood oxygen level dependent (BOLD) signal during picture viewing was recorded. When stimuli were presented repeatedly, participants showed a decrease in BOLD signal in brain areas that are specific to the processing of these stimuli due to habituation. Chinese participants showed greater adaptation in the left lateral occipital complex in response to incongruent than to congruent pictures, whereas American participants did not show this effect. In other words, Chinese participants showed greater object processing in the lateral occipital complex when these objects were presented against incongruent backgrounds than against congruent backgrounds. However, the same manipulation did not affect American participants. The researchers proposed that Chinese might be more sensitive to the context of a picture, and might pay greater attention to the object when the object and the background are not semantically congruent.

Taken together, evidence from behavioural, eye movement, and neuroimaging studies converge to suggest that East Asians demonstrate a tendency to pay attention to peripheral contextual information during visual tasks, whereas Western individuals are more likely to focus their attention on focal information. Moreover, individuals' memory for pictures is influenced by these culture-specific processing biases.

**Cultural Effects on Cognitive Aging**

Park et al. (1999) proposed that cultural differences in processes that require fewer cognitive resources should persist in old age. In contrast, cultural differences in highly effortful cognitive tasks should decrease with age. As tasks become more cognitively challenging, older adults need to allocate more cognitive resources to overcome age-related cognitive constraints. They may therefore have fewer cognitive resources to employ their culture-specific processing strategies, or to adopt new strategies that are not commonly used in their cultures. As a result, elderly from different cultures may show reduced cultural differences in effortful tasks.

This concept can be better understood through the lens of the mechanics-pragmatics distinction of cognition (Park & Gutchess, 2006; Park et al., 1999). The mechanics of cognition (or fluid intelligence) are metaphorically referred to as the basic "hardware" in processing, which includes speed of processing, working memory, inhibition, and other primary cognitive abilities, such as sensory information processing, visual and motor memory, and the discrimination, categorization, and organization of information (Baltes & Staudinger, 1993; Park & Gutchess, 2006; Park et al., 1999). These basic processes are strongly influenced by biological factors (e.g., genes, age-related neurological declines, and neurological trauma), and tend to decline with age (Baltes & Kliegl, 1986; Baltes & Staudinger, 1993).

Research indicates that although some types of mechanics vary with cultural experience in old age, many processing abilities show universal and cultural invariant declines with age. For example, some studies showed that there are greater aging effects than cultural differences in speed of processing, working memory, source memory (in which participants were asked to recall the identity of speakers in a video), and short term verbal memory (free-recall task; Park & Gutchess, 2006). Cultural differences are likely to appear in tasks of cognitive mechanics when task performance relies on culture-specific strategies. For instance, Hedden and his colleagues (2002) found a difference in performance on the forward and backward digit span tasks between American and Chinese young adults. Numeral digits in the Chinese language (e.g., Mandarin) contain fewer syllables than digits in English. The articulation rate for digits is therefore shorter in Chinese than in English. Research suggests that Chinese speakers, on average, can hold more digits in their working memory, and recall more items in digit span tasks, in comparison to English speakers (Hedden et al., 2002). Consequently, young Chinese participants demonstrated an advantage in both forward and backward digit span over their American counterparts. However, although older adults showed the same cultural differences in the forward digit span task as young adults, their performance on the backward digit span task was similar across cultures. The forward digit span task requires participants to recall a series of digits immediately after it is presented, whereas the backward digit span task assesses their ability to manipulate the digits in their working memory, and to recall the digits in the reverse order. The authors of this study suggest that the relatively high processing demands of the backward digit span task reduced the linguistic advantage of Chinese older adults, such that their linguistic advantage could no longer facilitate performance on the task. In contrast, the forward digit span task requires a lower working memory load and thus older adults could benefit from their cultural advantage, which may explain why the elderly participants exhibited cultural differences in this task, but not in the more challenging backward digit span task. This study demonstrates that for cognitively demanding tasks, cultural differences, if any, may be reduced in older adults. As mentioned previously, one plausible explanation is that universal age-related neurological declines may constrain elderly individuals' abilities to employ culture-specific strategies or knowledge as task demands increase (Park et al., 1999).

The pragmatics of cognition (or crystallized intelligence) is referred to as the "software" of processing – the knowledge one acquires through experience (Baltes & Staudinger, 1993; Park & Gutchess, 2006; Park et al., 1999). Some examples of cognitive pragmatics include language skills, professional skills (i.e., skills acquired through education or occupation), and knowledge about strategies that help to solve everyday problems (Baltes & Staudinger, 1993). Personal or cultural experiences can shape these knowledge-based processes and influence the overall processing style of an individual. Tasks that rely on pragmatics allow individuals to employ their personal experiences and skills, thus are less vulnerable to the effects of age (Park et al., 1999). In other words, acquired skills and knowledge could help older adults accomplish these tasks efficiently by subsidizing them against the effect of cognitive aging. For example, Gutchess and her colleagues (2006) found that there are cultural differences in the use of categorical organization in the free recall of words among Chinese and American participants, and the cultural differences were more pronounced in older adults than in young participants. In this study, the same word lists were presented to Chinese and American participants in Chinese and English, respectively. American participants, regardless of age, tended to group these words according to their taxonomic categories, whereas Chinese participants were less likely to use this strategy to facilitate recall. More interestingly, the cultural difference in the use of categorical organization was larger among older participants, in contrast to young participants. The researchers suggested that Western individuals are more familiar with using categorization in cognitive tasks in comparison to East Asians, and that Western elderly in particular are more experienced in employing this strategy than Western young adults. As a result, categorization is favoured and well-practiced in Western cultures, and has become an automatic processing strategy for older Americans. Chinese older adults, on the other hand, did not show a preference for utilizing categorical organization to aid recall. It is possible that the use of a less familiar strategy requires more cognitive resources, and is therefore difficult or less likely for older adults to adopt. With sufficient cognitive resources, young adults should be able to easily adopt different processing strategies, including those not preferred by their culture, and thus show smaller cultural differences in this task. Finally, it should be noted that although older adults from the two cultures used different approaches to accomplish the free recall task, their memory performance (i.e., the number of words recalled) was equivalent, indicating that despite cultural differences in preferred processing strategies, one strategy is not necessarily superior to another.

The distinction between mechanics and pragmatics can be further explained by the concept of cognitive resource limits. Norman and Bobrow (1975) proposed that performance on information processing tasks is affected by the amount of available cognitive resources (e.g., working memory capacity). If the amount of intrinsic cognitive resources is insufficient, task performance will suffer. This phenomenon can be seen in children, older adults, or individuals with cognitive deficits. In addition, task performance can also deteriorate as task difficulty increases. When task difficulty increases, one may engage in more than one cognitive process, and these processes may compete against each other for the limited resources available, resulting in poor task performance (Norman & Bobrow, 1975). In the same vein, age differences in available resources and task difficulty may interact to influence the effect of culture on task performance. With regard to the distinction between mechanics and pragmatics, task difficulty may be higher in cognitively demanding tasks that rely heavily on mechanics, as well as in complex tasks that engage several different pragmatic processes simultaneously. These tasks are particularly challenging because of the amount of intrinsic cognitive resources required. An example would be the aforementioned backward digit span task, in which participants need to memorize the digits and reverse the sequence of the digits at the same time. In contrast, tasks that do not involve multiple pragmatic processes allow more cognitive resources to be devoted to strategies that help to complete the tasks efficiently. That being said, individuals with higher cognitive resources, such as young adults, may be able to use both culturally favoured and culturally non-favoured strategies to solve cognitive tasks in both difficult and relatively simple tasks. On the other hand, older adults, who have lower cognitive resources than young adults, may only be able to apply both strategies in simple tasks that do not pose high burdens on their cognitive load. Nevertheless, older adults are speculated to have a stronger preference than young adults to employ their culturally favoured strategies to accomplish these tasks because of their life-long habit of engaging in these processes. It should also be noted that, when tasks become more complex (i.e., tasks that involve mechanic or multiple pragmatic processing), older adults may be limited to culturally favoured strategies, or may not be able to use any strategy at all. The interaction of available cognitive resources and task difficulty helps to explain the magnified or diminished cultural differences among older adults reported in previous studies.

In summary, cultural differences in cognitive processing may persist or decline with age. Cultural differences in more effortful tasks, such as those that rely heavily on cognitive mechanics, tend to decline with age. Age-related neurological declines, in addition to the demands of these tasks, may make it difficult for older adults to benefit from their culture-specific strategies (and thus cultural effects will be reduced; Hedden et al., 2002) or to adopt new, culturally non-favoured cognitive strategies to perform these tasks (and consequently cultural effects emerge or increase; Gutchess et al., 2006). In contrast, cultural differences in less effortful tasks (e.g., forward digit span task) or tasks that rely more heavily on acquired knowledge (i.e., pragmatics), may persist or even increase with age (due to older adults' longer exposure to their cultures in comparison to that of young adults). Through the investigation of the interaction of age and culture, we can further explore the influences of both age-related biological declines and experience accumulation on cognitive functioning. This will not only provide a fuller picture of universal cognitive aging, but will also inform the diversity in processing styles used by older adults across cultures.

**The Interaction of Age and Culture in Associative Memory**

As reviewed above, most studies investigating the interaction effect of age and culture on cognition focused on perception, attention, and basic fluid cognitive abilities. Little has been done to examine the interaction of aging and culture on associative memory – the binding of focal and peripheral information during memory encoding into one entity (e.g., Naveh-Benjamin, 2000; Old & Naveh-Benjamin, 2008). Previous studies indicate that the hippocampus is involved in the binding of information during encoding (e.g., Kroll, Knight, Metcalfe, Wolf, & Tulving, 1996), including binding of semantically related information (Henke, Weber, Kneifel, Wieser, & Buck, 1999), and in the retrieval of the bound information during recall and recognition tasks (e.g., Cutsuridis & Wennekers, 2009; Sadeh, Maril, Bitan, & Goshen-Gottstein, 2012). Moreover, age-related declines have been reported in associative memory – older adults often show deficits in memory binding in comparison to young adults (e.g., Chalfonte & Johnson, 1996; Cohn, Emrich, & Moscovitch, 2008; Naveh-Benjamin, 2000; Naveh-Benjamin, Guez, & Shulman, 2004; Naveh-Benjamin, Hussain, Guez, & Bar-On, 2003), despite their relatively intact item memory (Chalfonte & Johnson, 1996; Old & Naveh-Benjamin, 2008).

Chalfonte and Johnson (1996) speculated that age-related declines in associative memory might be due to older adults' deficiency in binding information coherently in memory for later retrieval. Naveh-Benjamin (1999) built on this idea by proposing the associative deficit hypothesis (ADH), suggesting that older adults, in comparison to young adults, have more difficulties in creating and retrieving associations between discrete units of information. Although they can remember single units of information (i.e., item memory) as efficiently as young adults, their performance suffers when the task requires them to remember associations between these units of information. In line with these speculations, neuroimaging studies revealed age differences in the activation of several brain regions during tasks that require binding of information. For instance, older adults show less activation in the left anterior hippocampus during a working memory task that requires information binding (Mitchell, Johnson, Raye, & D'Esposito, 2000). Age differences in the hippocampal and prefrontal regions during source memory tasks have also been demonstrated, whereby older adults show less activation in these areas in comparison to young adults (Dennis, Hayes, Prince, & Madden, 2008).

Although both behavioural and neuroimaging findings indicate age-related deficits in information binding and associative memory, it has been found that emphasis on associative strategies before encoding could attenuate the associative deficit in older adults (Naveh-Benjamin, Brav, & Levy, 2007). Specifically, Naveh-Benjamin and colleagues found that older adults' memory for word pairs improved when they were instructed to form meaningful semantic associations between the words to facilitate recall. This finding demonstrates that age-related declines in associative memory could be reduced with the use of appropriate associative strategies. It is thus logical to speculate that performance on associative memory tasks could also be affected by culture-specific strategies, whereby East Asians may show an advantage in some associative memory tasks relative to Western individuals due to their tendency to attend to relationships between objects and events.

To my knowledge, there are only a few studies that have examined cultural and aging effects on source memory. In Chua, Chen, and Park (2006), young and older Chinese and American participants watched video clips with statements spoken by distinct speakers. They were then asked to identify the source (i.e., the speaker) of the information. The results demonstrated universal age declines in source memory. American and Chinese older participants demonstrated similar age-related declines, indicating that there was no cultural difference in source memory in old age. It should be noted that in this study, the researchers arbitrarily assigned items to different sources, and there was no meaningful association between the items and these sources. This type of binding may pose higher demands on effortful biologically dependent cognitive processing, and thus might have minimized cultural effects.

In a recent source memory experiment, Yang and colleagues examined cultural effects on young and older adults' memory for categorically processed faces or words and their processing contexts (Yang, Chen, Ng, & Fu, 2013). In this intentional source memory experiment, participants encoded photographs of faces that were categorized as either good or evil. Their task was to identify whether each face presented at recognition had been seen earlier during encoding, and whether the face had been categorized as good or evil. In general, Canadians showed a better memory performance than Chinese on this task, and this cultural difference was larger among older than young participants. The results suggest that the preference of Western individuals for categorical processing becomes an advantage when tasks at hand require categorical processing skills. Furthermore, with their lifetime experiences with categorical processing, Canadian older adults performed as well as young adults in this experiment, whereas Chinese older adults showed age-related declines in the same task.

In another study, Yang and colleagues (2013) investigated age and cultural differences in two source memory tasks. In one task, Canadian and Chinese young and older adults were asked to either rate the meaningfulness of a list of items in an independent living context (e.g., living independently on one's own) or the typicality of the items in daily life. In another task, they were asked to rate the meaningfulness of a list of items in a context that promotes social relationships (e.g., getting along with others) or the typicality of the items in daily life. Participants were then asked to recognize the items and their associated contexts. It was found that Chinese showed a better memory for contextual information than Canadians, despite universal age-related declines in memory for both items and contexts. This finding indicates that Chinese' predisposition to socially meaningful contexts could facilitate their performance on tasks that involve holistic processing of socially meaningful item-context associations.

Taken together, these studies indicate that cultural effects on associative memory, specifically source memory, may appear when the cognitive task encourages culturally preferred strategies. In other words, Chinese may show an advantage when the task involves holistic processing of socially meaningful item-context associations whereas Western individuals may show an advantage when the task encourages categorical processing. These cultural differences may especially affect the performance of older adults on these tasks due to age-related declines in employing culturally non-favoured strategies.

**The Present Study**

It is apparent from the findings of the above studies that cultural bias in cognitive processing could influence our performance on associative memory tasks. However, it is still unknown how cultural variations would emerge under different manipulations of memory retrieval. The current study will take a novel perspective to examine cultural and age differences in memory under "unbinding", which is the isolation of incidentally encoded backgrounds and objects at recognition.

Age differences in unbinding effects were examined by Gutchess and Park (2009) in a study that aimed to investigate the effects of unbinding on associative memory. In one experiment of this study, young and older participants were instructed to study pictures that contained one focal object embedded in either a congruent or incongruent background. At recognition, the background scenes of half of these pictures were removed. This "unbinding" of the contextual information was expected to interfere with the participants' memory for the objects. Contrary to their hypotheses, the researchers found that (1) the congruency of the pictures did not affect picture memory in either age group, and that (2) unbinding, or the removal of contextual information, did not differentially impact the object recognition performance of the two age groups. In other words, unbinding of contextual information had similar negative effects on memory for objects from congruent and incongruent pictures in both age groups. The authors suggest that associative memory for complex pictures is invariant with age, which is inconsistent with previous findings that older adults performed poorer in associative memory tasks than young adults (e.g., Chalfonte & Johnson, 1996; Naveh-Benjamin, 2000). In other words, despite the fact that episodic memory generally declines with age, memory for complex pictures seems to be unaffected by aging.  This may suggest that memory for complex pictures is not dependent on biological processing mechanisms, and thus may be more vulnerable to the effect of experience or cultural differences. However, Gutchess and Park's (2009) study did not specify the ethnicity of their participants. Considering the study was conducted in the United States, it is very likely that their participants were mainly Western Caucasians. They did not investigate the cultural effects on age-related changes in associative memory under an unbinding manipulation.

Cultural differences in object and background binding during encoding have been investigated with an fMR-adaptation paradigm by Goh and colleagues (2007). Their study examined the neural structures involved in visual processing among young and older American and Singaporean participants. Participants viewed colour photographs of pictures that contained an object and a congruent background scene. These photographs were presented in quartets, and there were four experimental conditions: (1) identical object and scene pair presented repeatedly (OO, old object and old scene); (2) repeated object with four different scenes (ON, old object and new scenes); (3) repeated scene with four different objects (NO, new object and old scene); and (4) four novel object and scene pairs (NN, new objects and new scenes). Adaptation magnitude analyses were conducted to examine the difference in brain activation during the presentation of novel and repeated stimuli. The location of object-processing, background-processing, and binding regions were suggested by the difference in brain activation between ON and NN trials, NO and NN trials, and OO and NN trials, respectively. Older adults, but not young adults, from both cultures demonstrated decreased activity in the right hippocampus and right parahippocampal gyrus when they engaged in the binding of objects and backgrounds presented in the photographs during OO tasks in comparison to NN tasks. However, it is important to note that this particular study did not assess *memory binding* (i.e., memory for the associations between objects and their backgrounds). Although Goh and his colleagues (2007) did not find any significant main effects of age and culture on neural activity for background processing, Western older participants elicited a slightly lower adaptation response in the left parahippocampal gyrus in the NO-NN contrast than young participants from both cultures. East Asian older adults, on the other hand, demonstrated similar adaptation pattern as the young adults. This shows that there is some preserved background processing in East Asian older adults. The researchers suggested that cultural differences in background processing might become more apparent under tasks that require higher cognitive demands. Finally, this study also revealed that Western participants, regardless of age, demonstrated greater object-processing adaptation in the lateral occipital complex in ON tasks than East Asian older adults did. In fact, East Asian older adults showed almost no adaptation in the same area when processing objects. These cultural differences demonstrated at an early object-background binding stage, particularly at older age, may consequently affect individuals' memory for objects and backgrounds correspondingly.

Given the above, the present study will expand the study by Gutchess and Park (2009) to examine memory unbinding for complex pictures across Western and Eastern cultures. Specifically, the current study aims to examine whether East Asians' and Caucasians' memory for isolated focal objects and backgrounds will differ under unbinding; and if so, how cultural effects interact with age. Three research questions will be addressed in this study: (1) Do the two cultures differ in their memory for objects and background scenes in complex pictures under unbinding? (2) Do the two cultures differ in the effects of object-background congruency on memory for objects and backgrounds in complex pictures? (3) Is there an interaction between age and culture on memory for objects and backgrounds in complex pictures?

**Hypotheses of the Present Study**

Considering the substantial empirical evidence suggesting that Eastern Asians have greater sensitivity to contextual information than Western individuals (e.g., Nisbett et al., 2001), the following hypotheses are proposed for the current study: (1) Under unbinding, Chinese participants will recognize fewer images than Canadian participants. Unbinding at retrieval will be a disadvantage for Chinese participants, who have a tendency to encode focal and contextual information holistically as a whole. In contrast, Canadian participants will perform relatively well under unbinding because their preference for analytical processing promotes encoding of individual features (i.e., objects and backgrounds) as distinct entities. (2) The object-background congruency will affect recognition for objects and background scenes so that the elements from incongruent pictures will be better recognized than those from congruent pictures. This effect will be substantially larger for Chinese than for their Canadian counterparts, because East Asians were found to be more sensitive to picture congruency than Western individuals and they pay more attention to the objects when there is a lack of congruency between the objects and their contexts (Jenkins, et al., 2010). (3) Finally, the results of this study will inform whether cultural differences in memory unbinding will change with age. Due to the exploratory nature of the study, this is an open question. In other words, cultural differences in memory for objects and backgrounds under unbinding may diminish or intensify with age, or may be stable across the lifespan.

## Methods

### Participants

Four groups of participants, older and young Canadian and Chinese participants, were included in this experiment. We excluded individuals who (1) were taking medications that might influence their memory or attention, (2) were suffering from severe visual, auditory, or communicative impairments, (3) had a history of neurological disorders that might cause cognitive impairments, or (4) indicated difficulty seeing the green colour of the objects in the pictures during encoding. Furthermore, older individuals who scored below 26 on the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975) were also excluded, due to a concern of potential dementia-related cognitive impairments.

Canadian participants, consisting of only Caucasian Canadians of European descent, were tested in Toronto at Ryerson University. Thirty-six Canadian young participants (ages 18-28, $M = 20.58$, $SD = 2.77$; 10 males) were recruited either from the undergraduate psychology student participant pool at Ryerson University or through recruitment posters posted in the university. Student participants were compensated with partial course credit, whereas other participants received $10 per hour as compensation. Three young participants were replaced because the medication (e.g., antidepressant) they were taking might affect their performance in the study. One participant was replaced due to an experimenter error. Thirty-six Caucasian elderly participants (ages 65-90, $M = 72.72$, $SD = 5.94$; 12 males) were recruited from an internal elderly participant pool in the Department of Psychology at Ryerson University, and they received a compensation of $10 per hour for their participation. Ten Canadian older participants were replaced. Two of these older participants expressed difficulties seeing the colour of the objects. Three participants had either a medical history or were taking medication that might affect their performance in the experiment. One participant scored low on the MMSE. One participant was replaced because of an experimenter error and two participants were replaced because the computer program malfunctioned. One participant did not cooperate with the experimenter during testing, and was therefore replaced.

Thirty-six young (ages 18-26, *M* = 21.97, *SD* = 1.96; 15 males) and 36 older (ages 65-79, *M* = 70.75, *SD* = 3.57; 12 males) Han Chinese participants were tested at the Institute of Psychology, Chinese Academy of Sciences in Beijing, China. Chinese young participants were recruited from nearby universities in Beijing, through recruitment posters and advertisements on online school forums. Older participants were recruited in the local community through recruitment posters. Participants in Beijing received a compensation of 30RMB per hour for their participation. Chinese individuals from minority tribes (i.e., non-Han) were not included in this experiment. One young participant was replaced due to an experimenter error. Two older participants were replaced because of their visual impairments, and two older participants were replaced due to low scores on the MMSE.

The demographic characteristics and cognitive measures of the participants are reported in Table 1. The cognitive measures assessed in the study will be discussed in details in the Procedure section. Chinese young adults were older than Canadian young adults, $t(70) = -2.45$, $p = .017$. There was a significant interaction of age and culture in years of formal education, $F(1, 140) = 12.48$, $p = .001$, $\eta_p^2 = .082$. Canadian older adults had significantly higher years of formal education than Chinese older adults, $t(59.14) = 2.75$, $p = .009$. Levene's test revealed unequal variances ($F = 7.35$, $p = .008$), and therefore the degrees of freedom were adjusted. For young adults, Chinese participants had significantly more years of education than Canadian participants, $t(70) = -2.33$, $p = .023$. Canadian older adults had more years of education than Canadian young adults, $t(70) = 2.59$, $p = .012$, whereas Chinese young adults had more years of education than Chinese older adults, $t(47.65) = -2.46$, $p = .017$ (degrees of freedom were adjusted due to unequal variances indicated by the Levene's test, $F = 18.43$, $p < .001$).

Young adults were more accurate than older adults in their responses in the Corsi block task, $F(1, 140) = 97.70$, $p < .001$, $\eta_p^2 = .411$. There were age differences in the scores on the Positive Affect scale of the Positive and Negative Affect Schedule (PANAS), $F(1, 140) = 13.34$, $p < .001$, $\eta_p^2 = .087$, whereby older adults scored higher on the scale than young adults. There was also an age difference in the scores on the Negative Affect scale of the PANAS, whereby young adults scored higher on the scale than older adults, $F(1, 140) = 8.15$, $p = .005$, $\eta_p^2 = .055$.

As expected, there were significant cultural differences in both the independent, $F(140) = 10.66$, $p = .001$, $\eta_p^2 = .071$, and the interdependent scales, $F(140) = 31.43$, $p < .001$, $\eta_p^2 = .183$, of the Self-Construal Scale (SCS). Canadian participants scored higher on the independent scale than Chinese participants, whereas the opposite pattern was true for the interdependent scale. Older adults in general scored higher on the independent scale than young adults, $F(1, 140) = 10.66$, $p = .001$, $\eta_p^2 = .071$. In addition, Chinese older participants scored higher on the interdependent scale than Chinese young adults, $t(70) = 2.54$, $p = .013$.

There was an age difference in the scores on the Centre for Epidemiologic Studies Depression (CES-D) Scale, $F(1,140) = 15.57$, $p < .001$, $\eta_p^2 = .100$. Young adults scored higher on the scale than older adults. There was also an age by culture interaction, $F(1, 140) = 4.99$, $p = .027$, $\eta_p^2 = .034$, whereby Canadian young adults scored significantly higher than Canadian older adults, $t(60.99) = -4.53$, $p < .001$ (The degrees of freedom was adjusted due to unequal variances revealed by the Levene's test, $F = 8.21$, $p = .006$). There was no age difference in CES-D scores among Chinese participants.

Table 1

*Participant Characteristics*

| Measure | Canadian Young *M (SD)* | Canadian Old *M (SD)* | Chinese Young *M (SD)* | Chinese Old *M (SD)* |
|---|---|---|---|---|
| Age[C] | 20.58 (2.77) | 72.72 (5.94) | 21.97 (1.96) | 70.75 (3.57) |
| Corsi Block[a, A] | .56 (.19) | .30 (.17) | .60 (.20) | .27 (.15) |
| Years of Formal Education[b, AC] | 14.31 (2.27) | 15.78 (2.55) | 15.42 (1.75) | 13.61 (4.04) |
| PANAS-Positive Affect[c, A] | 25.17 (6.00) | 34.06 (6.62) | 28.56 (7.13) | 27.97 (7.45) |
| PANAS-Negative Affect[c, A] | 14.42 (6.21) | 11.78 (3.03) | 13.31 (4.32) | 11.89 (2.51) |
| SCS-Independent[d, A, C] | 4.72 (0.70) | 5.22 (0.64) | 4.50 (0.70) | 4.72 (0.62) |
| SCS-Interdependent[d, C, AC] | 4.61 (0.77) | 4.39 (0.69) | 4.94 (0.63) | 5.31 (0.58) |
| CES-D[e, A, AC] | 14.67 (8.18) | 7.25 (5.45) | 11.39 (7.20) | 9.33 (7.68) |
| MMSE[f] | – | 28.50 (1.16) | – | 28.28 (1.32) |
| Health Rating[g] | 7.72 (1.37) | 8.19 (1.51) | 7.83 (1.34) | 7.61 (1.25) |

*Note.* [A]Main effect of age. [C]Main effect of culture. [AC]Interaction of age and culture. [a]Corsi block scores range from 0 to 1, with higher scores indicating better visuospatial memory performance. [b]Years of formal education did not include years of continuing education. [c]PANAS = Positive And Negative Affect Schedule. Its scores range from 10 to 50, with higher scores indicating stronger affect. [d]SCS = Self-Construal Scale. Its scores range from 1 to 7, with higher scores indicating stronger values. [e]CES-D = Center for Epidemiologic Studies Depression Scale. Its scores range from 0 to 60, and higher scores indicate more depressive symptoms experienced in the past week. [f]MMSE = Mini-Mental State Examination. Possible scores range from 0 to 30. Higher scores are indicative of fewer dementia-related cognitive problems. [g]Health rating was self-reported, and range from 1 (“poor”) to 10 (“excellent”).

**Design**

All four groups of participants completed the same experimental procedures. The present experiment was a mixed-design study. Hit rates and recognition discriminability scores for object and background pictures were the dependent variables. There were four independent variables: age (young vs. old) and culture (Chinese vs. Canadian) were between-subjects variables, whereas the image type (background vs. object) and the stimulus type (congruent vs. incongruent) were within-subjects variables.

**Materials**

There were four sets of picture stimuli in the present study, consisting of 90 unique objects and 90 unique backgrounds. The first set of pictures contained 90 target objects (e.g., a cow), chosen from the stimulus set used in Gutchess and Park’s (2009) study. The second set of pictures contained 90 congruent pictures from Gutchess and Park’s study, in which each target object (from the first set of pictures) was presented against a congruent (i.e., semantically related) background (e.g., a cow in a farm). The background scenes of the pictures in the second set (congruent pictures) were swapped to create the third group of stimuli, in which each target object was then paired with an incongruent (i.e., semantically unrelated) background (e.g., a cow in a laundry room). A portion of these pictures has already been re-paired by Gutchess and Park (2009) to create pictures with semantically incongruent objects and backgrounds, whereas the rest of the pictures were re-paired in our lab for the same purpose. We had deliberately arranged these backgrounds such that participants would not be presented with the same background scene twice at encoding, while the themes (e.g., indoor, outdoor, underwater) and visual complexity (e.g., human figures, animals, inanimate objects, complexity of the backgrounds) of these pictures were matched at the same time. A few objects were not presented in the centre of the pictures, but participants’ attention were redirected to the centre of the pictures by the fixation cross regardless of the position of the objects, allowing for initial foveal attention. The colour of the objects in the second and third sets of pictures was modified from black to green. This was manipulated because a few pictures contained more than one object, and it might be difficult for participants to distinguish the focal objects from other objects in the backgrounds. Finally, to evaluate the memory for background scenes, the target objects were removed from the encoded pictures to create a fourth group of pictures that contained only background scenes (e.g., a farm), without the pairing objects. All the above manipulations of the picture stimuli were carried out using Adobe Photoshop CS5.

**Procedure**

All computerized tasks were programmed with E-prime 2.0. The stimuli were presented on 17” monitors of the PC system at both sites. Participants were tested individually in a testing room. Prior to testing, participants completed a consent form. The experiment started with an encoding task in which the participants viewed 60 sequentially presented pictures, including 30 congruent (i.e., objects paired with congruent backgrounds) and 30 incongruent pictures (i.e., objects paired with incongruent backgrounds). As illustrated in Figure 1, each trial started with a fixation cross presented at the center of the screen for 200 ms, then replaced by a complex picture presented for 2 seconds, followed by a blank screen as an interstimulus interval (ISI) for 800 ms, before proceeding to the next trial. Participants were instructed to look at these pictures as if they were watching television. There was no instruction given to guide their attention towards the objects or the backgrounds, and therefore the encoding of objects and backgrounds was incidental.

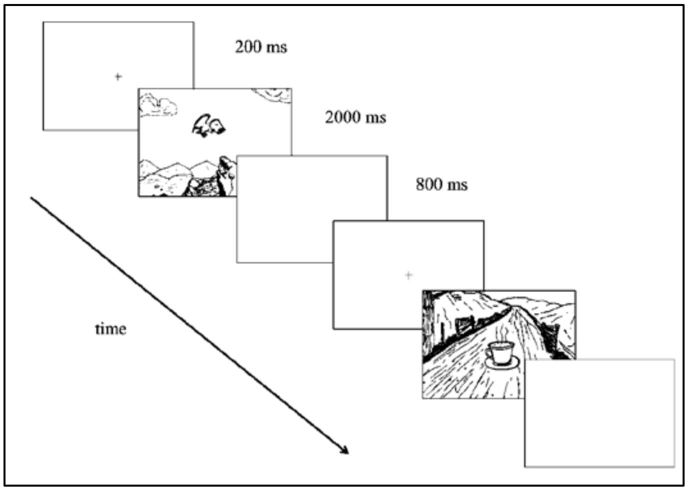


*Figure 1*. Illustration of the encoding task procedure. Congruent and incongruent pictures were presented at a rate of 2 seconds each, following a fixation cross. A blank screen was then presented as an interstimulus interval. Objects in the pictures were highlighted in green.

During the retention period, participants completed a computerized Corsi block task as a filler task and a measure of visuospatial working memory span (modified into a mouse version from Rowe, Hasher, & Turcotte, 2009), which lasted approximately 5 minutes. As recommended by Park and Gutchess (2002), the Corsi block task is a culturally invariant task that is suitable for measuring cognitive resources across cultures.

Following the retention period, two recognition tasks were administered (see Figure 2), with the order of the two tasks counterbalanced across participants. In the object recognition task, the participants viewed a set of pictures with only the target objects. There were 60 objects, including 30 objects from the encoded pictures (15 congruent and 15 incongruent pictures), and 30 new objects. In the background recognition task, the participants were presented with a set of pictures with only the background scenes. Similar to the object recognition task, there were 60 backgrounds, including 30 old background scenes from the encoded pictures (15 congruent and 15 incongruent pictures), and 30 new backgrounds. There was no repetition in the pictures shown in the two recognition tasks. At the beginning of both tasks, a fixation cross appeared in the middle of the screen for 1000 ms, followed by an image of an object or a background. The participants were asked to press two corresponding keys on a keyboard to indicate whether the object/background scene was an old picture that they had seen during the encoding task, or a new picture that they had not seen during encoding. The image stayed on the screen until the participants had made a response. In-between images, there was a blank screen for 800 ms, followed by a fixation cross for 200 ms. The previously studied pictures presented in the two conditions (i.e., congruent and incongruent) at encoding, as well as the unstudied new lure pictures at the recognition tasks were counterbalanced across participants, so that each picture was used equally often in each condition.

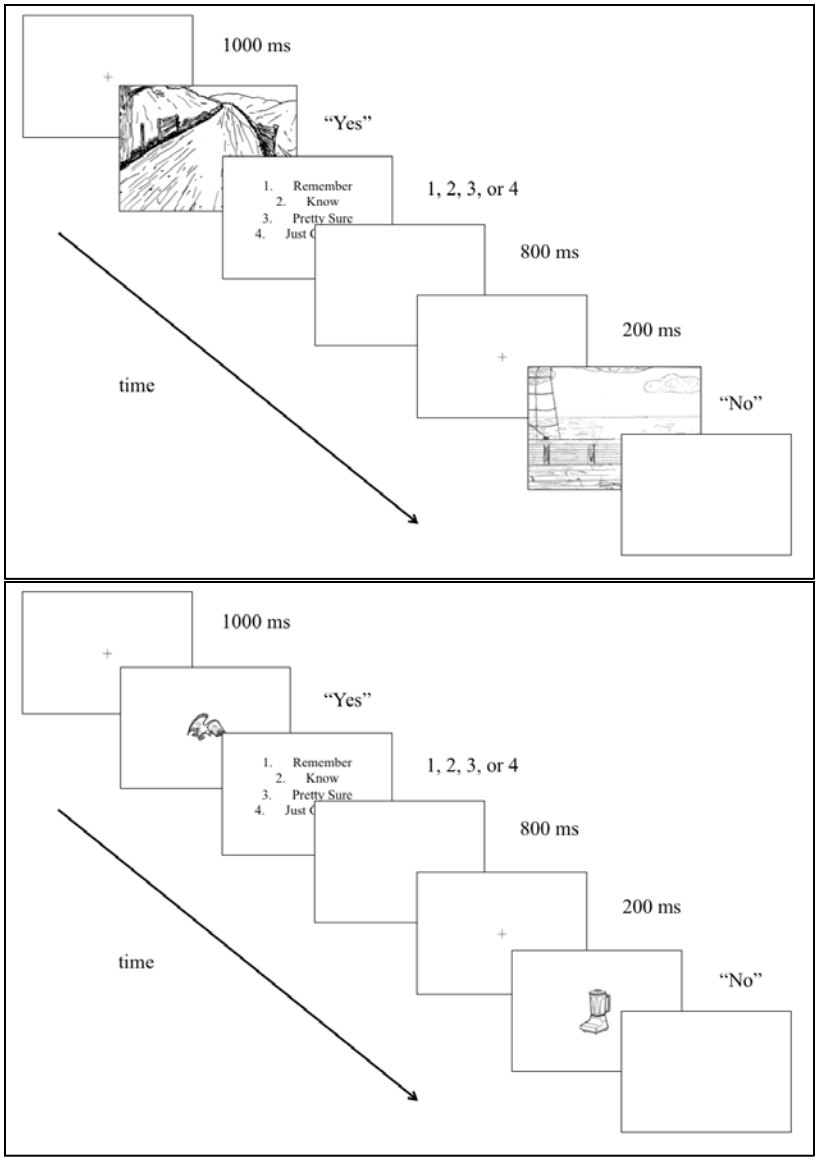


*Figure 2*. Illustration of the recognition task procedure. Background and object recognition tasks were counterbalanced. Participants were asked to indicate whether they had seen the image before by pressing *yes* and *no* keys. If they pressed *yes*, they were asked to indicate their level of confidence using number keys 1 to 4. Each image was followed by a blank screen and a fixation cross.

To assess participants’ level of confidence in their responses, we have included a confidence rating component in the recognition tasks. Due to the fact that the confidence rating task was introduced after the beginning of data collection, only 30 young and 30 older Canadian participants completed this task. On the other hand, all of the Chinese participants reported their confidence levels. During the recognition tasks, if the participants indicated that they had seen the image earlier, they were asked to rate their confidence in their response, using a 4-point Likert scale. Participants were instructed to: press the number key *1* at the top of the keyboard if they remember the moment that they have encountered the picture; press *2* if they feel sure that the picture has been presented, without specific memory; press *3* if they are pretty sure, but not certain, that they have seen the picture; and press *4* if they are just guessing. The instructions were repeated and further explained if a participant asked for clarifications.

After the completion of the two recognition tasks, participants went through a self-paced congruency rating task. During this task, the complete set of 180 pictures, including all the congruent and incongruent pictures, was presented on the computer screen one after another. The purpose of this task was to examine whether participants across the two cultures agree on the congruency between the objects and their backgrounds. Participants were instructed to look at each picture and rate how typical (i.e., usual or likely) it was for the object to appear in the scene, by pressing two corresponding keys (labelled as “typical” and “not typical”). To clarify the task, participants were instructed to respond “not typical” when they do not normally expect the object to appear in the scene. However, this response does not necessarily mean that the object could never possibly appear in that scene. Participants were also reassured that there was no right or wrong answer, and their responses should be based on their personal opinion. To familiarize participants with the task, four practice trials, including two congruent and two incongruent pictures, were provided at the beginning of this task. Immediately after the rating task, the experimenter asked participants whether they have been able to see the green colour of the objects in the pictures, to ensure that they have not encountered difficulties distinguishing the focal objects from the background scenes.

At the end of the experimental session, participants completed a battery of paper-and-pencil measures and questionnaires. The Positive and Negative Affect Schedule (PANAS) was used to assess the mood of the participants at the moment of testing (Watson, Clark, & Tellegen, 1988). The Self-Construal Scale (SCS) was administered to assess the degree of independency and interdependency of an individual's self-construal (Singelis, 1994). The Center for Epidemiologic Studies Depression Scale (CES-D) was used to measure the participants' level of depressive symptomatology within the past week (Radloff, 1977). The Mini-Mental State Examination (MMSE) was used with the older participants in this study as a screen test for potential dementia-related cognitive impairments (Folstein et al., 1975). All participants completed a background demographic questionnaire, which included a question regarding their ethnical background. In this questionnaire, participants were also asked to indicate whether they had been expecting a memory test during encoding, and whether they had paid attention to the green object, the background, or both the object and background in the pictures. These two questions provided insight into the encoding strategies employed by participants across cultures. Finally, participants were debriefed and compensated.

The instructions for the memory task and the Corsi block task were translated to Chinese for the Chinese participants of this study. The Chinese instructions were also back-translated to English to ensure accuracy. The corresponding Chinese versions of all the paper-and-pencil measures and questionnaires were administered to Chinese participants.

**Statistical Design**

All statistical analyses in this study were conducted using SPSS 20.0. The significance level was set at .05 for all analyses, and effects with significance levels between .05 and .10 were reported as marginally significant.

**Recognition performance.** The main dependent variable of this study was the hit rates to the target objects or backgrounds. A mixed model 2 (age: young vs. old) x 2 (culture: Chinese vs. Canadian) x 2 (image type: background vs. object recognition) x 2 (stimulus type: congruent vs. incongruent images) analysis of variance (ANOVA) was conducted to investigate the effects of age and culture on recognition for congruent and incongruent backgrounds and objects. Age and culture were between-subjects variables, whereas image type and stimulus type were within-subjects variables. A 2 (age: young vs. old) x 2 (culture: Chinese vs. Canadians) x 2 (image type: background vs. object recognition) ANOVA was then conducted to examine differences in false alarm rates across age and cultural groups.

To further investigate the recognition accuracy of participants, *A'* and *B"* scores were calculated for background and object recognition. *A'* and *B"* are nonparametric alternatives to *d'* and *c*, respectively. These nonparametric alternatives were chosen because some participants had false alarm rates of 0, which violated an assumption of the parametric measures. *A'* is a measure of response discriminability, which examines participants' recognition accuracy while accounting for false alarm rates (Stanislaw & Todorov, 1999). *B"*, on the other hand, is a measure of response bias, which indicates whether participants had a general tendency toward *yes* or *no* responses during the recognition tasks (Stanislaw & Todorov, 1999). Both *A'* and *B"* scores were calculated using hit rates and false alarm rates in adherence to the procedures outlined in Stanislaw and Todorov (1999). It should be noted that for both background and object recognition in these analyses, recognition accuracy rates for congruent and incongruent images were averaged. This is because the lure images in the background recognition and object recognition tasks were new images that were not presented at encoding, and thus they are neutral and do not possess congruency attributes. As a result, respective *A'* and *B"* scores for congruent and incongruent pictures could not be calculated. Mixed model 2 (age: young vs. old) x 2 (culture: Chinese vs. Canadian) x 2 (image type: background vs. object recognition) ANOVAs on *A'* and *B"* scores were conducted respectively, with age and culture as between-subjects variables and image type as a within-subjects variable.

**Level of confidence in recognition.** Participants' level of confidence in their recognition responses was analyzed using a mixed model 2 (age: young vs. old) x 2 (culture: Chinese vs. Canadian) x 2 (image type: background vs. object recognition) x 2 (stimulus type: congruent vs. incongruent images) ANOVA, with age and culture as between-subjects variables and image type and stimulus type as within-subjects variables. The dependent variable in this analysis was participants' confidence rating, which ranged from 1 to 4. Lower confidence ratings indicate higher confidence in recognition. The confidence rating was analyzed as a continuous scale, as opposed to past studies (e.g., Rajaram, 1996), because the purpose of this task was to compare participants' overall levels of confidence in their recognition accuracy across age and cultural groups. As aforementioned, 30 young and 30 older Canadian participants completed this confidence rating task during recognition, whereas all Chinese participants completed the task. Canadian participants who did not complete the confidence rating task were excluded from these analyses.

**Ratings of congruency of pictures.** The dependent variables in the congruency rating task were participants' agreement with the congruency attributes of the pictures and reaction time. Participants rated the pictures in this experiment as either congruent (i.e., "typical") or incongruent (i.e., "not typical"). Their ratings were compared with the actual congruency of the pictures. Agreement scores were calculated for congruent and incongruent pictures separately. The scores ranged from 0 to 1, and they represented the proportion of pictures that were rated "correctly" (e.g., a congruent picture rated as "typical") by each participant. A mixed model 2 (age: young vs. old) x 2 (culture: Chinese vs. Canadian) x 2 (stimulus type: congruent vs. incongruent pictures) ANOVA was conducted to compare participants' agreements with the congruency of the pictures. Participants' reaction time in the rating task was measured and analyzed using a mixed model 2 (age: young vs. old) x 2 (culture: Chinese vs. Canadian) x 2 (stimulus type: congruent vs. incongruent pictures) ANOVA. Age and culture were between-subjects variables, and stimulus type was a within-subjects variable.

**Self-report attention allocation during encoding.** At the end of testing, participants were asked whether they paid more attention to objects, backgrounds, or both objects and backgrounds of the pictures during encoding. Only one Canadian young adult indicated that she paid more attention to backgrounds than objects. However, her background recognition performance was not better than that of her peers, as her corrected recognition score for backgrounds ($M$ = .10) was lower than the group mean of young Canadian participants ($M$ = .28). Ninety-seven participants indicated that they only paid attention to objects, whereas 46 participants paid equal attention to objects and backgrounds. Chi-square analysis indicated that there was no association between age and culture and the choice of encoding strategy (i.e., which component of the picture to pay attention to).

To assess the effect of attention allocation during encoding on recognition performance, a mixed model 2 (image type: object vs. background) x 2 (age: young vs. old) x 2 (culture:

Chinese vs. Canadian) x 2 (encoding strategy: object vs. both object and background) ANOVA was conducted. The dependent variable in this analysis was *A'* scores, in which false alarm rates were accounted for. Age, culture, and encoding strategy were between-subjects variable, whereas the image type was a within-subjects variable. Only one participant reported more attention paid to backgrounds, and thus this participant was excluded from this analysis.

## Results

The results of this experiment are reported in the following sections. The effects of age and culture on recognition accuracy for objects and backgrounds are presented in the first section, followed by group differences in participants' level of confidence in their recognition. The results of the congruency rating task are presented in the third section. Participants' attention allocation during encoding is reported in the fourth section. Lastly, possible confounding factors in this experiment, including expectation of memory tests, performance on the visuospatial task (Corsi block task), self-construal values, mood during experiment, and education levels, are further explored in the last section.

### Recognition Accuracy for Objects and Backgrounds

**Hit rates.** Hit rates to congruent and incongruent background and object images are presented in Table 2.

Table 2

*Hit Rates and False Alarm Rates*

| | Canadian | | Chinese | |
|---|---|---|---|---|
| | Young | Old | Young | Old |
| Image | *M (SD)* | *M (SD)* | *M (SD)* | *M (SD)* |
| | | Hit Rates | | |
| Backgrounds | | | | |
| Congruent | .59 (.20) | .59 (.18) | .57 (.17) | .51 (.21) |
| Incongruent | .56 (.16) | .54 (.18) | .56 (.17) | .48 (.23) |
| Objects | | | | |
| Congruent | .69 (.19) | .81 (.12) | .71 (.14) | .72 (.20) |
| Incongruent | .67 (.20) | .79 (.13) | .69 (.17) | .71 (.19) |
| | | False Alarm Rates | | |
| Backgrounds | .30 (.13) | .31 (.18) | .38 (.20) | .37 (.21) |
| Objects | .20 (.12) | .20 (.14) | .22 (.20) | .20 (.18) |

The mixed ANOVA indicated a main effect of image type, $F(1, 140) = 167.58$, $p < .001$, $\eta_p^2 = .545$. Objects were better recognized than backgrounds. There was also a main effect of stimulus type, $F(1, 140) = 5.70$, $p = .018$, $\eta_p^2 = .039$. Images from congruent pictures, in general, were better recognized than those from incongruent pictures. There was a significant two-way interaction of image type and age (see Figure 3), $F(1, 140) = 16.96$, $p < .001$, $\eta_p^2 = .108$. Post-hoc *t*-test analyses were conducted to examine age differences in background and object recognition. Age differences in recognition accuracy only appeared in the object recognition. Older adults across cultures recognized significantly more objects than young adults, $t(142) = 2.65$, $p = .009$. In contrast, there was no age difference in background recognition.

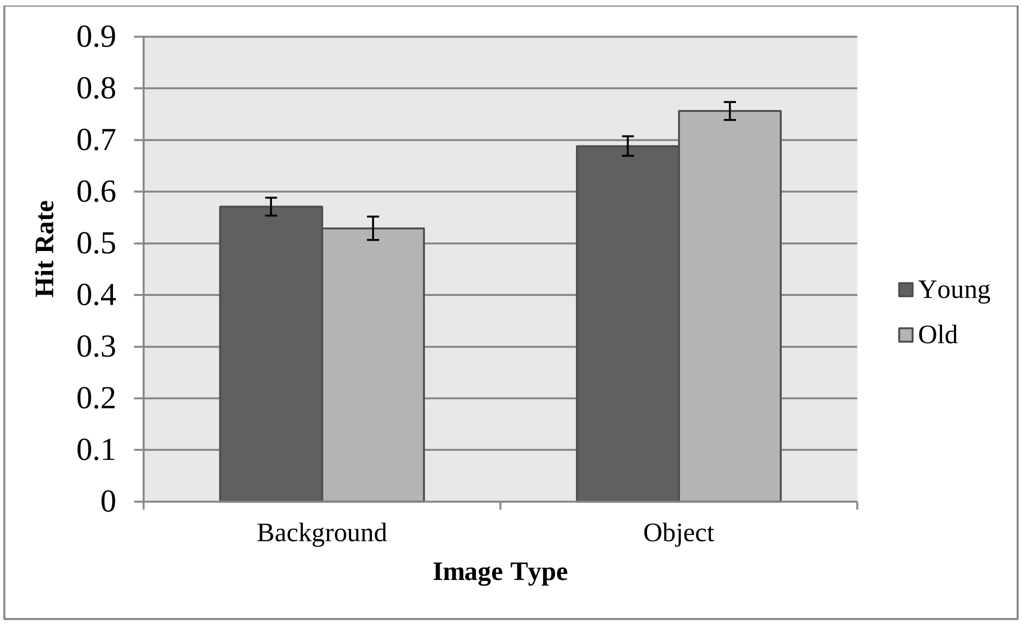


*Figure 3.* Interaction of age and image type on recognition accuracy. Error bars represent standard errors.

Finally, it should be noted that there was a marginally significant two-way interaction of age and culture (see Figure 4), $F(1, 140) = 3.23$, $p = .075$, $\eta_p^2 = .023$. Post-hoc *t*-tests revealed that Canadian older adults showed an overall better recognition than Chinese older adults, $t(55.88) = 2.31$, $p = .024$. The Levene's test revealed unequal variances ($F = 7.68$, $p = .007$) and therefore the above degrees of freedom were adjusted. There was also a trend for Canadian older adults to perform better than Canadian young adults in overall recognition, $t(62.01) = 1.83$, $p = .072$. The degrees of freedom were adjusted due to unequal variances revealed by the Levene's test ($F = 8.09$, $p = .006$).

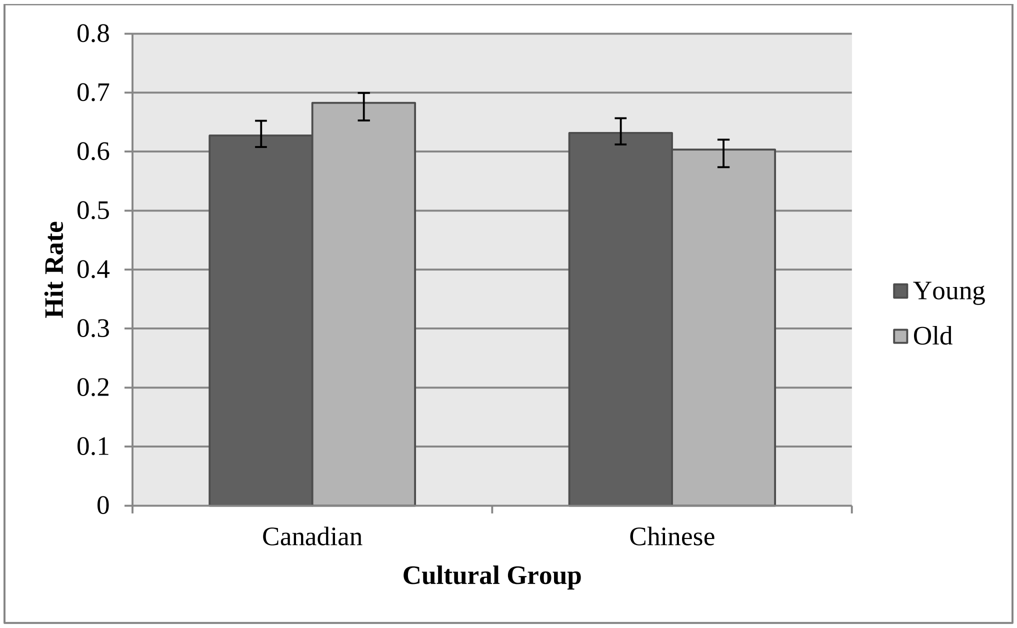


*Figure 4.* Marginally significant interaction of age and culture on recognition accuracy. Error bars represent standard error.

**False alarm rates.** The false alarm rates in each age by culture group are displayed at the bottom panel of Table 2. There was a main effect of image type, $F(1, 140) = 90.91$, $p < .001$, $\eta_p^2 = .394$, in which there were more false alarms for backgrounds than for objects. Although the main effect of culture was not significant, there was an interaction effect of image type and culture (see Figure 5), $F(1, 140) = 4.35$, $p = .039$, $\eta_p^2 = .030$. Chinese participants generated more false alarms towards backgrounds than Canadian participants, $t(132.89) = -2.31$, $p = .023$. The above degrees of freedom were adjusted because of unequal variances as indicated by the Levene's test, $F = 4.15$, $p = .044$. Conversely, there was no cultural difference in false alarms for objects.

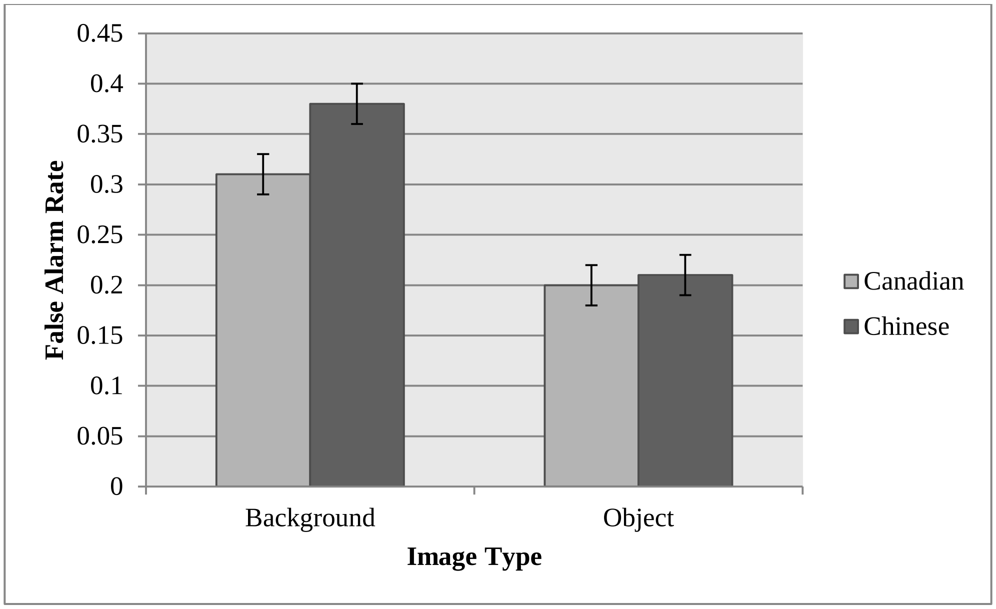


*Figure 5.* Interaction of culture and image type on false alarm rates. Error bars represent standard errors.

**Response discriminability (*A'*).** *A'* scores are presented in Table 3.

Table 3

*Response Discriminability (A') and Response Bias (B")*

| | Canadian | | Chinese | |
|---|---|---|---|---|
| | Young | Old | Young | Old |
| Image | *M (SD)* | *M (SD)* | *M (SD)* | *M (SD)* |
| | Response Discriminability (*A'*) | | | |
| Backgrounds | .71 (.13) | .70 (.10) | .66 (.10) | .61 (.13) |
| Objects | .82 (.09) | .88 (.05) | .82 (.09) | .85 (.07) |
| | Response Bias (*B"*) | | | |
| Backgrounds | .10 (.20) | .12 (.23) | .06 (.20) | .05 (.25) |
| Objects | .14 (.37) | .09 (.44) | .21 (.40) | .14 (.48) |

*Note: A'* scores range from 0.5 to 1. Scores of 0.5 indicate a chance level of sensitivity to distinguish between old and new images. Scores of 1 indicate perfect performance. *B"* scores range from -1, representing extreme bias towards *yes* responses, to 1, representing extreme bias towards *no* responses.

The mixed ANOVA on *A'* scores revealed a main effect of image type, $F(1,140) = 319.71$, $p < .001$, $\eta_p^2 = .695$, in which participants were more able to discriminate between old and new objects than between old and new backgrounds. Interestingly, there was also a main effect of culture, $F(1, 140) = 10.56$, $p = .001$, $\eta_p^2 = .070$. Canadian participants showed higher response discriminability than Chinese participants. The emergence of the cultural effect in recognition after false alarm rates were controlled for is plausibly due to a higher false alarm rate in Chinese than in Canadian participants.

There were also two interaction effects: an image type by culture interaction (see Figure 6), $F(1, 140) = 9.04$, $p = .003$, $\eta_p^2 = .061$, and an image type by age interaction (see Figure 7), $F(1, 140) = 10.69$, $p = .001$, $\eta_p^2 = .071$. Post-hoc analyses revealed that cultural differences only appeared in background recognition, $t(142) = 3.72$, $p < .001$, whereby Canadians performed better than Chinese in discriminating between old and new backgrounds. In contrast, age differences only appeared in object recognition, $t(130.83) = 2.82$, $p = .005$, and older adults showed higher recognition discriminability towards objects than young adults. The above degrees of freedom were adjusted due to unequal variances (Levene's $F = 7.33$, $p = .008$). Despite these significant two-way interaction effects, the three-way interaction of image type, culture, and age was not significant, $F(1, 140) = 0.10$, $p = .750$, $\eta_p^2 = .001$.

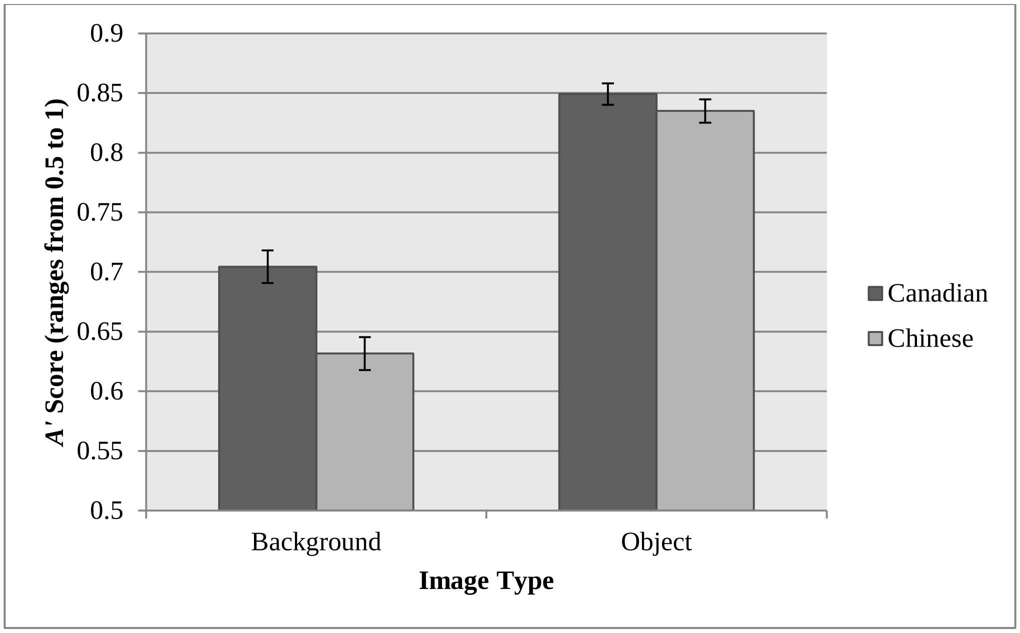


*Figure 6.* Interaction of image type and culture on *A′* scores. Error bars represent standard errors.

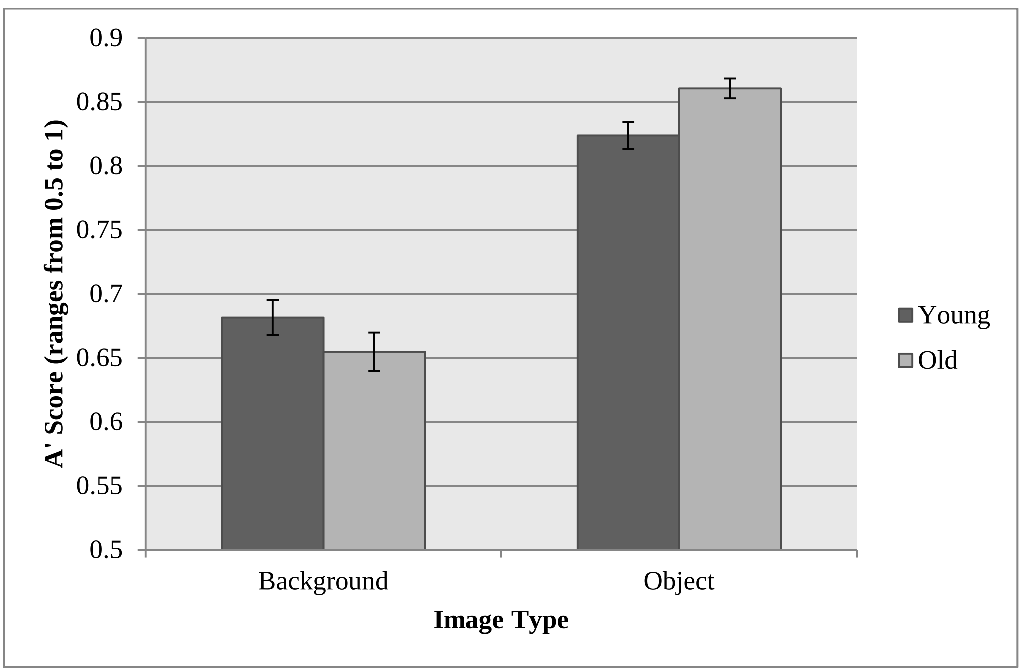


*Figure 7*. Interaction of image type and age on *A′* scores. Error bars represent standard errors.

**Response bias (*B”*).** Participants' *B”* scores are presented in Table 3. The mixed ANOVA revealed only one main effect – the main effect of image type, $F(1, 140) = 4.49$, *p*

= .036, $\eta_p^2$ = .031. Participants in general were more likely to favour *yes* responses (i.e., indicating an image as an old image seen at encoding) in the background recognition than in the object recognition task. Other main effects or interactions did not reach significance, suggesting that response bias held by participants across age and cultural groups did not differ in this experiment.

**Summary.** First of all, objects were better recognized than backgrounds. Not surprisingly, participants in general were more likely to respond *yes* towards background images than object images, and their false alarm rates for backgrounds were higher than those for objects. Second, images from congruent pictures were also better remembered than images from incongruent pictures.

Age and cultural differences in recognition performance were also found. Unexpectedly, older adults across cultures showed better recognition for objects than young adults, reflected in both of their hit rates and recognition discriminability (i.e., *A'* scores). Furthermore, Canadian participants recognized more images than Chinese participants, but only after false alarms were controlled for in the *A'* analysis. However, it should be noted that this cultural effect only appeared in background recognition. In fact, we found that Chinese participants produced more false alarms than Canadian participants in background recognition. This may primarily account for the cultural differences in *A*' scores. Finally, there was a marginally significant age by culture interaction effect, whereby Canadian older adults outperformed the other three groups of participants in overall recognition accuracy.

## Level of Confidence in Recognition Responses

Participants' levels of confidence in their recognition responses are presented in Table 4. As aforementioned, participants rated their confidence on a scale of 1 to 4 if they have indicated the image as old. Lower numbers on the scale represent higher degree of confidence.

Table 4

*Participants' Confidence in Recognition Responses*

| | Canadian | | Chinese | |
|---|---|---|---|---|
| | Young | Old | Young | Old |
| Measure | *M (SD)* | *M (SD)* | *M (SD)* | *M (SD)* |
| Backgrounds | 2.07 (0.50) | 2.08 (0.68) | 2.03 (0.54) | 1.90 (0.64) |
| Objects | 1.67 (0.45) | 1.64 (0.66) | 1.56 (0.33) | 1.44 (0.45) |

The mixed ANOVA revealed a main effect of image type, $F(1, 128) = 112.86$, $p < .001$, $\eta_p^2 = .469$. Participants were more confident in their recognition for objects than that for backgrounds. There was no cultural or age differences in participants' level of confidence in their recognition performance.

**Effects of the confidence rating task on recognition performance.** It is possible that the addition of the confidence rating component in the recognition tasks had an effect on participants' recognition responses. Without the confidence rating task, participants were simply asked to indicate whether the image had appeared at encoding by pressing the *Yes* and *No* keys. If they were uncertain, they were asked to make a guess and choose between the two responses. The confidence rating task allowed participants to press *Yes* when they were not certain, because one of the responses was *just guessing* (Response *4*). As a result, participants who completed the recognition tasks with the confidence rating component might be more likely than those who completed only the recognition tasks to report that they had seen an image earlier when they were guessing. To eliminate this possibility, recognition performance was re-analyzed, excluding participants (6 young and 6 older Canadian participants) who did not complete the confidence rating component. This exclusion did not change any of the effects on recognition performance reported above.

***Just guessing* responses: An indication of uncertainty.** It is also of interest to examine whether participants across age and cultural groups differed in their *just guessing* responses. Whereas some participants might follow instructions and make a guess when they were not certain whether an image had been presented previously, others might be more inclined to report they had not seen the image (by pressing *No*) under the same circumstance. A mixed model 2 (age: young vs. old) x 2 (culture: Chinese vs. Canadians) x 2 (image type: background vs. object recognition) x 2 (recognition type: old vs. new images) ANOVA was conducted to examine cultural and age differences in guessing responses. Due to the unequal number of correct responses and false alarms produced by participants, the *proportion* of "just guessing" responses among all confidence rating responses by each participant was calculated for each image type (i.e., backgrounds and objects) and recognition type (i.e., old and new images). This was calculated by dividing the number of *just guessing* responses by the total number of confidence rating responses within each condition. A few participants (1 young and 1 older Canadians; 2 young and 2 older Chinese) did not make any false alarms, and therefore were not included in this analysis. As a result, 29 young and 29 older Canadians and 34 young and 34 older Chinese participants were included in this analysis. Proportions of guessing responses to backgrounds and objects are reported in Table 5.

Table 5

*Proportion of* Just Guessing *Responses Relative to All Confidence Rating Responses*

| | Canadian | | Chinese | |
|---|---|---|---|---|
| | Young | Old | Young | Old |
| Image | *M (SD)* | *M (SD)* | *M (SD)* | *M (SD)* |
| Backgrounds | | | | |
| Old | .12 (.14) | .15 (.18) | .11 (.13) | .10 (.14) |
| New | .20 (.25) | .21 (.19) | .17 (.17) | .15 (.21) |
| Objects | | | | |
| Old | .05 (.11) | .08 (.19) | .05 (.06) | .04 (.06) |
| New | .24 (.29) | .27 (.27) | .16 (.20) | .08 (.16) |

Results of this analysis indicated a main effect of image type, $F(1,122) = 6.98$, $p = .009$, $\eta_p^2 = .054$, in which participants were more likely to produce the *just guessing* responses to background images than object images. This demonstrates that not only were participants less able to recognize backgrounds than to objects, they were also more uncertain about their memory for backgrounds. There was also a main effect of recognition type, $F(1, 122) = 48.63$, $p < .001$, $\eta_p^2 = .285$. Not surprisingly, there was a higher proportion of *just guessing* responses towards new images in comparison to old images. A main effect of culture was also revealed, $F(1, 122) = 5.49$, $p = .021$, $\eta_p^2 = .043$, in which Canadian participants showed a higher proportion of guessing responses to both old and new images than Chinese participants.

There were two interaction effects – an interaction of image type and culture (see Figure 8), $F(1, 122) = 4.88$, $p = .029$, $\eta_p^2 = .038$, and an interaction of recognition type and culture (see Figure 9), $F(1, 122) = 5.42$, $p = .022$, $\eta_p^2 = .042$. Specifically, Canadian participants were more likely than Chinese participants to produce guessing responses to object images, $t(93.68) = 2.71$, $p = .008$. Remarkably, Canadian participants also showed a higher proportion of guessing responses than Chinese participants towards new images, $t(102.44) = 2.57$, $p = .012$, which indicates that Chinese participants were more confident about their recognition responses despite their higher rates of false alarms. The above degrees of freedom were adjusted due to unequal variances as indicated by the Levene's tests ($F = 7.61$, $p = .007$, and $F = 6.67$, $p = .011$, respectively).

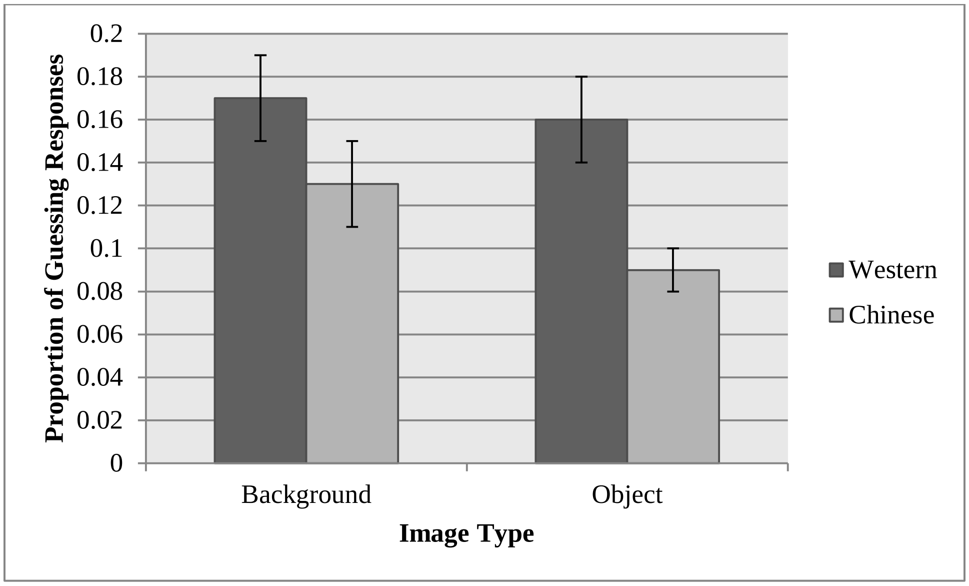


*Figure 8*. Interaction of image type and culture on proportion of guessing responses. Error bars represent standard errors.

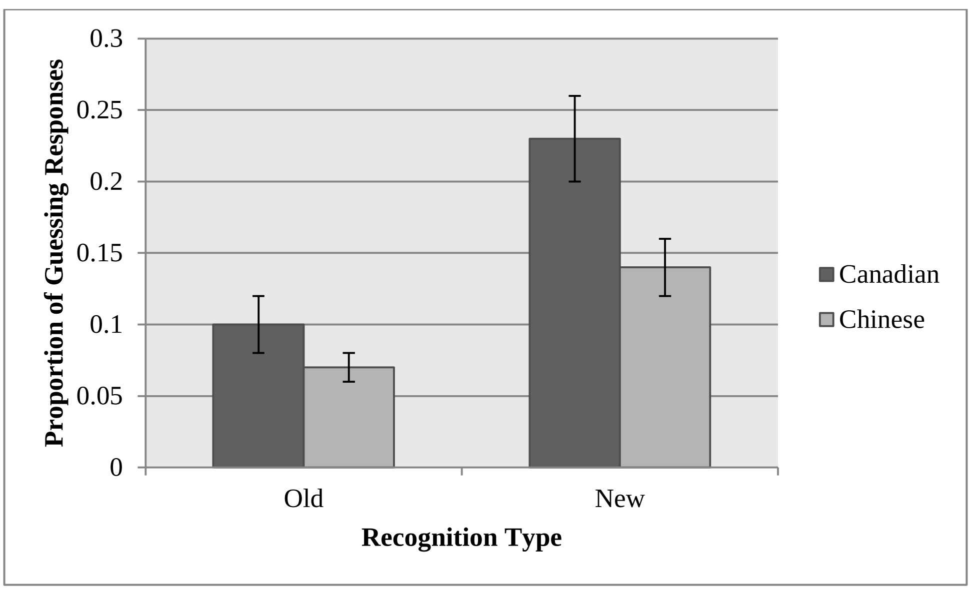


*Figure 9.* Interaction of recognition type and culture on proportion of guessing responses. Error bars represent standard errors.

Intuitively, participants who produced a high proportion of *just guessing* responses might be more likely to produce false alarms, because of their tendency to make guesses. However, bivariate correlation analysis revealed no association between false alarm rates and proportion of guessing responses. Finally, recognition accuracy was reanalyzed after eliminating trials with *just guessing* responses, but the reported main and interaction effects remained the same. This suggests that the cultural difference in background recognition was not related to cultural bias in guessing at recognition.

**Summary.** Participants were more confident about their memory for objects than their memory for backgrounds. They also produced fewer guessing responses to objects than backgrounds. Secondly, Canadian participants produced more guesses than Chinese participants in object recognition. Canadian participants were also more likely than Chinese participants to guess when a new, unseen image was presented, albeit Chinese participants showed a higher false alarm rate. Nevertheless, our follow-up analyses indicated that the proportion of guessing responses produced was not correlated with false alarm rates. Furthermore, removing trials with these guessing responses did not affect the age and cultural effects on recognition performance.

### Ratings of Congruency of Pictures

Participants' rating agreement scores are presented in Table 6.

Table 6.

*Participants' Agreements with the Congruency of the Pictures*

| | Canadian | | Chinese | |
|---|---|---|---|---|
| | Young | Old | Young | Old |
| Congruency | *M (SD)* | *M (SD)* | *M (SD)* | *M (SD)* |
| Congruent | .90 (.06) | .91 (.06) | .84 (.06) | .79 (.11) |
| Incongruent | .91 (.05) | .89 (.07) | .77 (.12) | .69 (.14) |

Canadian participants showed a significantly higher level of agreement with the congruency of pictures than Chinese participants, $F(1, 140) = 232.48$, $p < .001$, $\eta_p^2 = .624$. Second, young adults were more likely to agree with the congruency of pictures than older adults, $F(1, 140) = 18.15$, $p < .001$, $\eta_p^2 = .115$. There was also a main effect of stimulus type, $F(1, 140) = 13.66$, $p < .001$, $\eta_p^2 = .089$, in which the level of agreement with congruent pictures was higher than that with incongruent pictures.

As illustrated in Figure 10, there was an interaction of stimulus type and culture, $F(1, 140) = 9.62$, $p = .002$, $\eta_p^2 = .064$, and an interaction of culture and age, $F(1, 140) = 13.81$, $p < .001$, $\eta_p^2 = .090$. Specifically, Canadian participants showed higher levels of agreement with the congruency of both congruent, $t(120.22) = 7.21$, $p < .001$, and incongruent pictures, $t(98.78) = 9.73$, $p < .001$, than Chinese participants. The above degrees of freedom were adjusted as the Levene's tests indicated unequal variances ($F = 13.64$, $p < .001$ and $F = 28.58$, $p < .001$, respectively). Chinese participants had a higher level of agreement with congruent pictures than incongruent pictures, $t(71) = 3.71$, $p < .001$. This pattern was not significant in Canadian participants. Canadian young and older participants showed a higher overall level of agreement with the congruency of pictures than their Chinese counterparts, $t(70) = 9.05$, $p < .001$ and $t(70) = 12.30$, $p < .001$, respectively. Chinese young adults also had a higher level of agreement with picture congruency than Chinese older adults, $t(70) = -5.00$, $p < .001$. Age difference in rating agreement was not significant for Canadian participants.

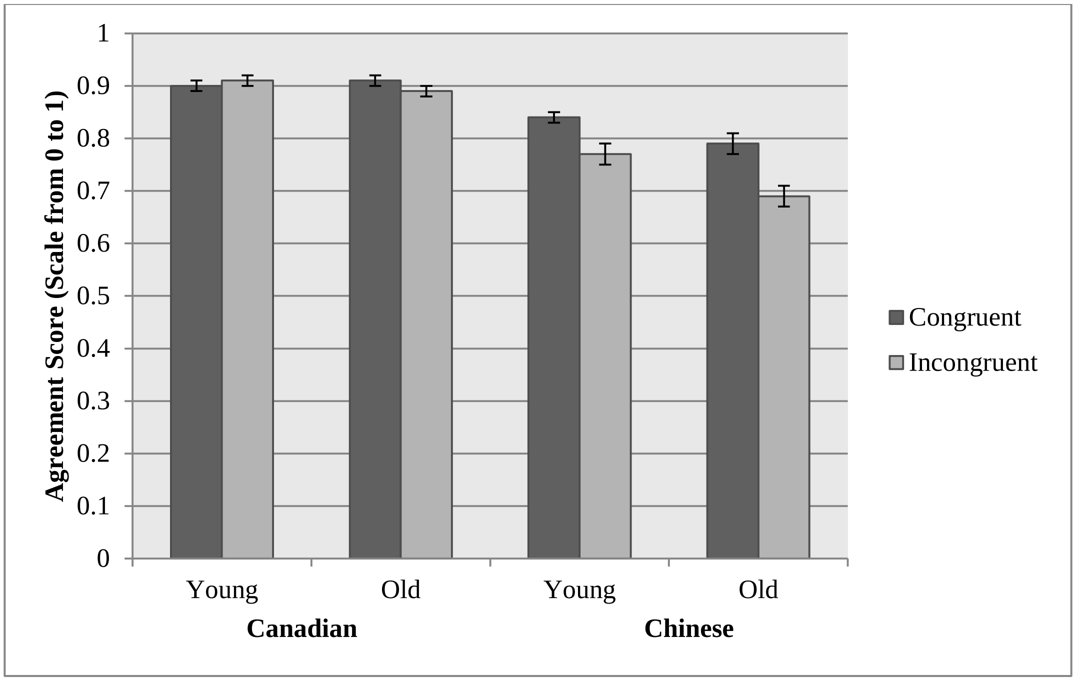


*Figure 10.* Agreement scores on congruency of pictures across age and cultural groups. Error bars represent standard errors.

**Reaction time in congruency rating.** Participants' reaction times in the congruency rating task are reported in Table 7.

Table 7.

*Participants' Reaction Times (ms) in the Congruency Rating Task*

| | Canadian | | Chinese | |
|---|---|---|---|---|
| | Young | Old | Young | Old |
| Congruency | *M (SD)* | *M (SD)* | *M (SD)* | *M (SD)* |
| Congruent | 1585 (495) | 2917 (1278) | 2122 (712) | 4159 (2934) |
| Incongruent | 1570 (471) | 2585 (1015) | 2146 (648) | 4145 (2311) |

The mixed ANOVA revealed significant main effects of age, $F(1, 140) = 42.85$, $p < .001$, $\eta_p^2 = .234$, and culture, $F(1, 140) = 16.11$, $p < .001$, $\eta_p^2 = .103$. Older participants were slower than young participants; and Chinese participants were also slower than Canadian participants in the rating task. The slower rating response time of Chinese participants might indicate their unfamiliarity with the pictures, which were originally used with Western participants.

**Removal of pictures with low agreement rating.** Canadian and Chinese participants' mean rating agreement scores on each picture were analyzed. Seventeen out of 180 pictures contained mean rating agreement scores lower than .50 in either Canadian or Chinese participant group. It was likely that participants were guessing the congruency of these pictures by chance. Chinese participants' mean rating scores on all of these 17 pictures were below .50. Canadian participants also showed low level of agreement in four of the 17 pictures. Congruency rating performance (accuracy and reaction time), as well as recognition accuracy (hit rates and *A'*) result patterns remained the same even after removing the recognition responses to the objects and backgrounds of these pictures. In other words, excluding these pictures did not change any of the significant main effects and interactions reported earlier.

**Summary.** First, young adults were faster than old adults at the congruency rating task. Canadian participants showed higher agreements in picture congruency rating than Chinese participants. They also rated the pictures more quickly than Chinese participants. Chinese participants agreed more with the congruency of congruent pictures than that of incongruent pictures. Moreover, young Chinese adults showed higher agreements than older Chinese adults. In fact, among all participants, older Chinese adults showed the lowest agreements with the congruency of the pictures. Given these data, there was a concern than cultural differences in recognition performance might be driven by cultural differences in picture interpretation. Our follow-up analyses did not support this speculation, as cultural differences in recognition performance remained that same even after excluding pictures with low agreement in congruency ratings.

**Attention Allocation at Encoding**

The encoding strategy employed by participants was determined by a self-report measure, in which participants were asked to indicate which part of the picture they had paid attention to during encoding (i.e., object, background, or both). Table 8 presents the number of participants who paid attention to objects only and those who paid attention to both objects and backgrounds, as well as their respective recognition performance (*A'* scores). As aforementioned, only one participant paid attention to backgrounds during encoding, and was therefore excluded from the analysis.

Table 8.

*A' Scores of Participants Who Paid Attention to Objects Only and Participants who Paid Attention to Both Objects and Backgrounds*

| | Canadian | | Chinese | |
|---|---|---|---|---|
| | Young | Old | Young | Old |
| Image | M (*SD*) | *M (SD)* | M (*SD*) | *M (SD)* |
| | Attention to Objects | | | |
| | *n* = 21 | *n* = 24 | *n* = 27 | *n* = 25 |
| Backgrounds | .68 (.14) | .68 (.11) | .66 (.10) | .61 (.13) |
| Objects | .82 (.10) | .88 (.05) | .83 (07) | .86 (.07) |
| | Attention to Objects and Backgrounds | | | |
| | *n* = 14 | *n* = 12 | *n* = 9 | *n* = 11 |
| Backgrounds | .76 (.10) | .75 (.06) | .65 (.11) | .60 (.14) |
| Objects | .83 (.06) | .86 (.05) | .80 (.14) | .81 (.08) |

The mixed ANOVA revealed an interaction effect of image type and encoding strategy (see Figure 11), $F(1, 135) = 8.28$, $p = .005$, $\eta_p^2 = .058$. Participants who paid equal attention to backgrounds and objects during encoding elicited higher *A'* scores in background recognition than participants who paid more attention to objects, $t(141) = -2.08$, $p = .040$. However, differences in attention allocation did not influence participants' response discriminability. In other words, participants using different encoding strategies showed equivalent memory for objects. Strikingly, the ANOVA also indicated an interaction effect of culture and encoding strategy (see Figure 12), $F(1, 135) = 4.39$, $p = .038$, $\eta_p^2 = .031$. Canadians who paid attention to both objects and backgrounds during encoding showed higher *A'* scores than those who only paid attention to objects, $t(67.36) = -1.82$, $p = .047$. The above degrees of freedom were adjusted because of unequal variances as indicated by the Levene's test, $F = 5.64$, $p = .020$. This effect of encoding strategy, however, was not significant among Chinese participants.

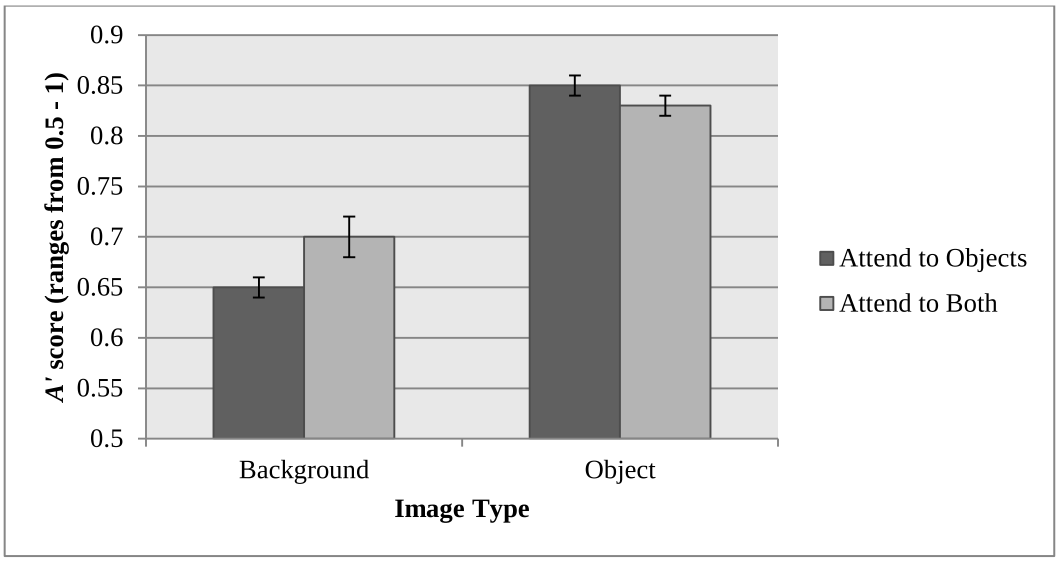


*Figure 11.* Interaction effect of image type and encoding strategy. Error bars represent standard errors.

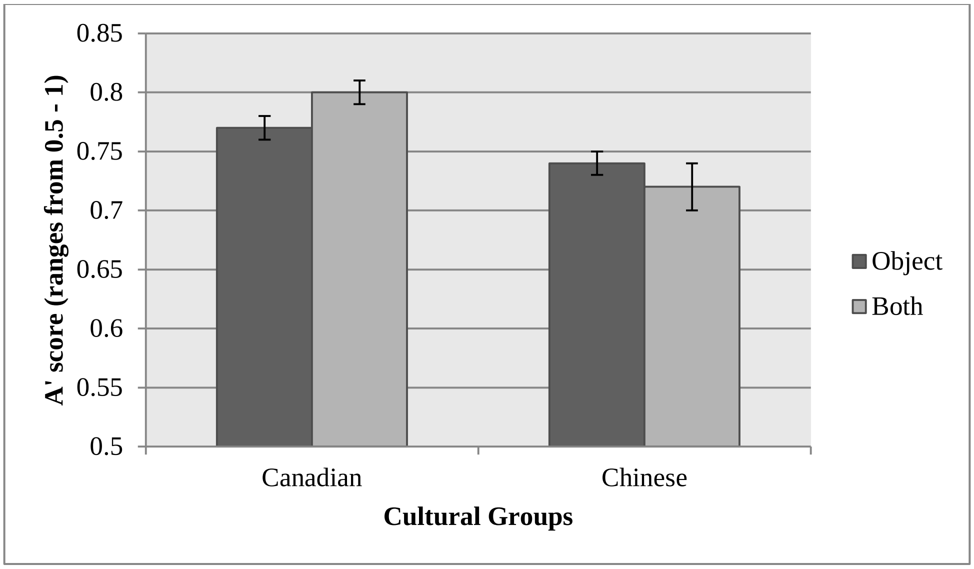


*Figure 12.* Interaction effect of culture and encoding strategy. Error bars represent standard errors.

**Possible Confounding Variables**

As reported above, there were age and/or cultural differences in several variables, including participants' expectation of subsequent memory tests, performance on the visuospatial working memory test (i.e., Corsi block test), self-construal scales, mood during experiment, and levels of formal education. To evaluate whether these variables mediated the effects of age and culture on recognition performance, bivariate correlation and mediation analyses were conducted and reported below.

**Expectation of memory tests.** Although participants were not told about the recognition tests before encoding, they might have expected a memory test when they were studying the pictures because they were not asked to make any responses during encoding. Indeed, most participants (34 old and 32 young Canadians; 31 old and 29 young Chinese) had foreseen some type of memory tests on the encoded pictures. To test the influence of participants' expectation of the later memory tests and their recognition performance, a chi-square analysis was conducted to examine cultural and age differences in their expectations. The analysis did not reveal any age and cultural difference in expectations, indicating that participants across cultures and age groups were just as likely to anticipate the later memory tasks.

**Performance on the Corsi block task.** As aforementioned, the Corsi block task assesses participants' visuospatial working memory span. Young participants in this study outperformed older adults on this task. A bivariate correlation analysis was conducted to investigate the relation between participants' visuospatial working memory span and object recognition performance (i.e., *A*' scores), which both showed age differences. The result of this analysis did not indicate any significant correlation between performance on the Corsi block task and *A*' scores for objects, $r = -.061$, $p = .471$.

**Self-construal scores.** As aforementioned, Canadian participants scored higher on the independent scale of the SCS, whereas Chinese participants scored higher on the interdependent scale. Bivariate correlation analyses were conducted to examine the association between self-construal scores and recognition performance (i.e., *A*' scores). There was no correlation between the two self-construal scores and recognition performance ($p > .10$ for all correlations).

**Mood.** There were age and cultural differences in participants' mood at testing, as measured using the PANAS. Older adults generally had a higher positive affect than young adults, whereas young adults had a higher negative affect than older adults. Past research has demonstrated that positive affect leads to a broadened attention allocation to peripheral or distracting information (e.g., Rowe, Hirsh, & Anderson, 2007). Given these findings, bivariate correlation analyses were conducted to investigate the association between mood during testing and *A*' scores as well as the association between depressive mood (i.e., CES-D scores) and recognition performance (i.e., *A*' scores). Results indicated a significant negative correlation between CES-D scores and *A’* scores for backgrounds, $r = -.164$, $p = .05$, and *A*’ scores for objects, $r = -.283$, $p = .001$. Participants with more depressive symptoms showed worse recognition for backgrounds and objects. Mediation analyses were conducted following Hayes’ method documented on his website (Hayes, n.d.) to examine the possibility that the effects of culture and age on recognition performance were mediated by participants’ levels of depressive symptoms (i.e., CES-D scores). Levels of depressive symptoms were a significant predictor of performance on background recognition, $t = -2.23$, $p = .028$. However, participants’ culture was not a significant predictor of depressive symptoms, $t = -0.47$, $p = .641$. Furthermore, the effect of culture on performance on background recognition remained significant, $t = -3.86$, $p < .001$, after controlling for the effect of depressive symptoms. On the other hand, the effect of age on object recognition was mediated by the effect of depressive symptoms. As illustrated in Figure 13, the effect of age attenuated and became marginally significant, $t = -1.88$, $p = .062$, after the effect of depressive symptoms, $t = -2.78$, $p = .006$, was accounted for.

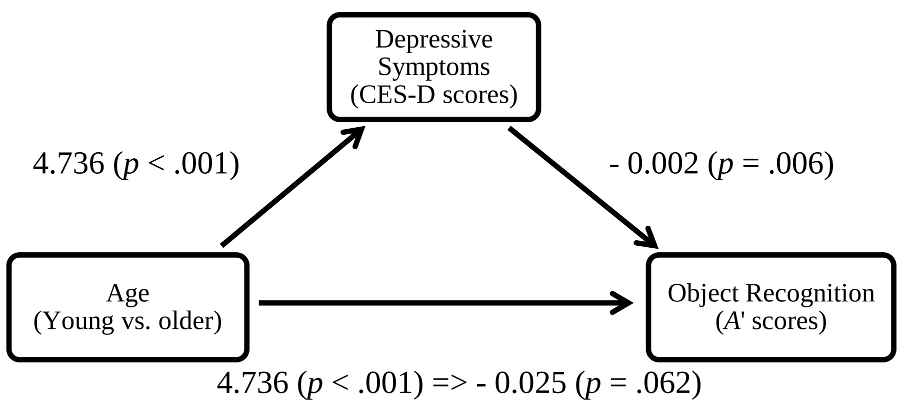


*Figure 13.* The mediating effect of levels of depressive symptoms on the relationship between age and object recognition performance. Regression coefficients were presented with the corresponding *p* values in parentheses.

**Education.** As reported in the Methods section, there were both cultural and age differences in the number of years of formal education in the sample. A bivariate correlation analysis was conducted to examine the relationship between years of formal education and *A'* scores for backgrounds and objects. Number of years of formal education was positively correlated with *A'* scores for both backgrounds ($r = .236$, $p = .005$) and objects ($r = .204$, $p = .014$). Mediation analyses were conducted to investigate whether years of formal education mediated the relationship between culture and background recognition or between age and object recognition. The analyses revealed that neither culture nor age was significant predictor of education levels, $t = -1.10$, $p = .274$, and $t = 0.35$, $p = .731$, respectively. Although years of formal education were a significant predictor of background recognition performance, $t = 2.71$, $p = .008$, the effect of culture on background recognition remained significant, $t = -3.54$, $p < .001$, after controlling for the effect of education levels. Likewise, years of formal education were a significant predictor of object recognition performance, $t = 2.75$, $p = .007$, but the effect of age remained significant, $t = -2.97$, $p = .004$, after the effect of education was accounted for.

**Summary**. In sum, participants' expectation of subsequent memory tests did not differ across age and cultural groups. Although there were group differences in self-construal values and in performance on the Corsi block task, neither variable correlated with recognition performance. Years of formal education were positively correlated with both background and object recognition. Mediation analyses also indicated years of formal education as a significant predictor of background and object recognition accuracy. However, the effects of culture and age on recognition performance remained significant after levels of formal education were accounted for, suggesting that education levels did not mediate the relation between culture and background recognition, and between age and object recognition. Lastly, mood during testing, as measured with the PANAS, was not correlated to recognition performance. Nevertheless, depressive symptoms (i.e., CES-D scores) were negatively correlated to both background and object recognition, whereby participants with more depressive symptoms performed worse in the recognition tasks. Depressive symptoms were found to be significant predictors of both background and object recognition performance. They may also partially mediate the effect of age on object recognition, in which the age affect became marginally significant after CES-D scores were controlled for.

## Discussion

In the present study, age and cultural differences in picture memory under an unbinding condition were examined. Under unbinding, participants recognized isolated, unbound objects and backgrounds from encoded pictures. This study aimed to address three questions: (1) Do the two cultures differ in their memory for objects and background scenes in complex pictures under unbinding? (2) Do the two cultures differ in the effects of object-background congruency on memory for objects and backgrounds in pictures? (3) Do the culture effects, if any, on memory for unbound objects and backgrounds in pictures change with age?

### General Recognition Performance under Unbinding

All participants in this study, regardless of age and cultural background, showed better recognition for objects than backgrounds, as well as fewer false alarms for objects than for backgrounds. As part of the instruction of the encoding task, participants were informed that they would see pictures with a green object and a background scene. Given that the colour of the objects was mentioned, it is possible that this instruction directed participants' attention to the objects. Furthermore, the green objects were contrasted from the black and white background scenes, which made the objects more distinctive to participants than the backgrounds. Objects might also be better remembered because they were perceptually smaller and more integrated (i.e., less dispersed) than backgrounds. Taken together, encoding of objects in the present study was a relatively intentional task, whereas encoding of background scenes was incidental in nature.

### Cultural Differences in Memory under Unbinding

Past research has revealed that Western individuals, in comparison to East Asians, tend to process information in an analytic style, by which distinctive features or components (e.g., focal objects vs. backgrounds) were processed independently (e.g., Masuda & Nisbett, 2001). As a result, recognizing images under unbinding may be consistent with their accustomed processing style. In contrast, East Asians prefer to process information holistically and tend to integrate and bind different features as a whole (e.g., Masuda & Nisbett, 2001), thus unbinding at retrieval may violate their default information processing style. As a result, their memory performance under unbinding would suffer. This hypothesis was supported by our findings. Canadian participants recognized more images in general than Chinese participants. In addition, follow-up analyses revealed that the effect of culture was only shown in background recognition, but not in object recognition. Moreover, cultural difference in recognition appeared only after false alarms rates were controlled for. This indicates that Chinese participants were more likely than Canadian participants to incorrectly recognize a new image as an image they had previously viewed. In fact, Chinese participants generated more false alarms towards background images than Canadian participants. Additionally, Chinese participants elicited fewer guessing responses to new images in general, despite that they produced a higher number of false alarms to new backgrounds than Canadian participants. However, the two cultural groups did not differ in response bias, suggesting that the cultural difference in false alarm rates was not due to a tendency to respond *yes* among Chinese participants. Taken together, these findings suggest that it was more difficult for Chinese participants to differentiate between old and new background images, possibly due to an abstract representation of background images in their memory trace.

Chinese participants’ tendency to holistically bind objects and backgrounds could also be observed in their congruency rating of the pictures. They were slower than Canadian participants in the self-paced rating task, which may indicate that they were more careful in their rating responses than Canadian participants. However, their rating agreements were lower than those of

Canadian participants. Furthermore, they showed lower agreements with the congruency of incongruent pictures than that of congruent pictures. In other words, Chinese participants showed a tendency to rate incongruent pictures as congruent. This suggests that they are inclined to associate the objects and backgrounds in a meaningful way, even when the objects and backgrounds are not meant to relate to each other.

As predicted, participants who paid attention to both objects and backgrounds of the pictures at encoding recognized more backgrounds than those who only paid attention to objects. However, paying attention to objects, in comparison to both objects and backgrounds, did not improve participants' memory for objects. Despite that there was no cultural difference between the self-reported encoding strategies employed by participants across cultures, Canadian participants who paid attention to both objects and backgrounds recognized more images in general (i.e., objects and backgrounds) than Canadian participants who only paid attention to objects. In contrast to Canadian participants, Chinese participants' memory did not benefit from paying equal attention to both objects and backgrounds. This cultural difference is possibly due to cultural bias in information binding. When attending to both objects and backgrounds, Canadians might have encoded the two pieces of information as distinct features or components. Weaker bindings of objects and backgrounds in turn promoted Canadians' memory under unbinding, in which objects and backgrounds were to be recognized separately. On the other hand, Chinese participants might have encoded objects and backgrounds holistically as one entity due to a default tendency to pay attention to both elements, even when some of them reported to have only paid attention to objects during encoding. As a result, their actual attention allocation at encoding might not be related to their self-reported encoding strategy, and thus there was no difference in recognition performance between Chinese participants who only paid attention to objects and those who paid equal attention to both objects and backgrounds.

It is important to note that our follow-up analyses indicated a lack of cultural difference in recognition for objects. It is likely that the green colour of the objects have drawn attention of participants, regardless of their cultural background, to the objects. Recognition for backgrounds, on the other hand, might be more prone to the effect of unbinding because backgrounds were not as distinctive as objects during encoding. Furthermore, Chinese participants were more likely to bind and integrate backgrounds with the objects than Canadian participants. As a result, Chinese participants might have formed holistic, or gestalt-like, representations of the pictures. Unbinding impaired their memory for backgrounds especially, because the backgrounds were not as intensively encoded as the objects. This explains the cultural difference in background recognition, but not in object recognition.

Cultural difference in background recognition might also be due to Chinese participants' lower familiarity with the picture stimuli. All the picture stimuli used in this study were adapted from Gutchess and Park's (2009) study, which was conducted in the United States with a sample of primarily Western people. Some objects in these pictures, such as golf clubs, squirrel, and totem, are not common in China. In comparison to Canadian participants, Chinese participants were less likely to rate congruent pictures as congruent and incongruent pictures as incongruent. Unfamiliarity with the objects might have drawn their attention to focus on the objects at the expense of paying less attention to background scenes. To eliminate this possibility, pictures with low accuracy in congruency rating (average rating agreement score less than .50 in any group of participants) were removed from the analysis. However, removal of these pictures did not affect the above cultural difference in recognition discriminability for backgrounds.

Follow-up analyses revealed that depressive symptoms were negatively correlated with recognition discriminability for backgrounds. However, the effect of culture remained significant after controlling for the effect of depressive symptoms. In other words, the effect of culture on background recognition performance was not mediated by participants' depressive symptoms. Secondly, education was also found to be positively correlated with recognition discriminability for backgrounds, which indicates that participants with higher years of formal education performed better in the background recognition task. Nevertheless, the effect of culture on background recognition remained even after education levels were accounted for in a mediation analysis. This demonstrates that cultural difference in recognition for backgrounds was not due to variations in education levels.

**Effect of Aging on Recognition under Unbinding**

Remarkably, a perplexing age difference was found, in which older adults outperformed young adults in recognition for objects. This main effect of age appeared in both hit rates and recognition discriminability for objects, which demonstrates that older adults' better performance was not due to higher false alarm rates in comparison to young adults. Furthermore, the effect of age remained significant even after controlling for education levels. There was no age difference in the confidence rating of recognition responses, response bias, and congruency rating agreements, suggesting that effect of age on recognition for objects was not likely to be confounded by these variables. It should be noted, however, that depressive symptoms (i.e., CES-D scores) were negatively correlated with recognition discriminability for objects, which indicates that participants with more depressive symptoms performed poorer in the object recognition task. Moreover, mediation analysis revealed that the effect of age on object recognition performance decreased and became marginally significant after the effect of depressive symptoms was controlled for. This indicates that the effect of age on object recognition might be partially mediated by depressive symptoms, which were significantly more severe among young adults than older adults.

The finding that levels of depressive symptoms partially mediated the effect of age on object recognition is interesting. Indeed, this finding is not consistent with past findings that encoding is more focused and less likely to be distracted by peripheral information when under negative moods than under positive moods (e.g., Rowe et al., 2007). On the contrary, our finding indicates that participants with more depressive symptoms remembered fewer focal objects than participants with fewer symptoms. One plausible explanation is the difference in motivation between participants with more depressive symptoms and those with fewer symptoms. It has been documented that patients with depression showed less motivation in accomplishing cognitive tasks (as reviewed by Austin, Mitchell, & Goodwin, 2001). It is possible that participants who felt more depressed were less focused during encoding, which impaired their memory for focal objects later on.

Although it was found that age differences in object recognition in the present study were mediated by levels of depressive symptoms, it is important to note that the effect of age on object recognition was still marginally significant after depressive symptoms were controlled for. It is possible that young adults showed poorer recognition for objects than older adults because they bound objects and backgrounds together more successfully than older adults. Age-related decline in associative memory has been reported in several studies (e.g., Chalfonte & Johnson, 1996; Naveh-Benjamin et al., 2004; Old & Naveh-Benjamin, 2008). It has also been found that both Western and East Asian older adults show diminished activities in the hippocampus during binding of objects and backgrounds (Goh et al., 2007). Furthermore, it has been documented that associative memory (e.g., memory for context, source memory) shows differentially larger age-related deficits relative to item memory (Old & Naveh-Benjamin, 2008). At the encoding phase of the present study, young adults might have integrated the objects with the backgrounds and formed a more united representation of the pictures in their memory trace. Considering that the association between objects and backgrounds was stronger among young adults, removal of backgrounds from objects at recognition would impair their memory for objects more drastically than that of older adults. On the other hand, because older adults were less efficient at binding objects with the backgrounds during encoding, they might have processed the objects and backgrounds separately as two distinct entities. As a result, removal of one element of the picture did not impact the memory for another element for older adults. This speculation explains the finding that older adults outperformed young adults in recognition for objects under unbinding. It is also in line with previous findings (e.g., Chalfonte & Johnson, 1996; Davenport & Potter, 2004).

In Davenport and Potter's (2004) study, participants were shown coloured photographs for a very brief duration, and were instructed to identify the objects or backgrounds in the photographs immediately after each picture was presented. Participants showed a higher accuracy in the identification of objects when the objects were shown in isolation at encoding than when they were shown with background scenes. Davenport and Potter suggested that objects and backgrounds are processed interactively at an early time, even when binding of the two pieces of information is not necessary; therefore, the presence of backgrounds might interfere with perception of objects. In other words, participants' attention was solely focused on the objects when backgrounds were absent, but the binding of objects and backgrounds at encoding diverted participants' attention from the objects, which impaired their processing of the objects. In the same vein, effective binding of objects and backgrounds during encoding in the present study might have drawn participants' attention away from the objects, and deficiency in binding might allow participants to process and remember the objects and backgrounds individually as separate entities.

The above speculation is further supported by Chalfonte and Johnson's study conducted in 1996. In a series of experiments, young and older participants viewed 30 line-drawing objects in different colours simultaneously and were later tested on their memory for the objects, colours, or the combination of the objects and their associated colours. Older adults' recognition for objects (i.e., item memory) and the colour of the objects (i.e., feature memory) were more accurate than their recognition for the association of the objects and their colour (i.e., associative memory). In fact, older adults' memory for objects and colours was as accurate as young adults', albeit apparent age-related deficits in associative memory. This suggests that even though older adults are able to remember individual item and feature information, they show difficulties binding the two pieces of information together into one cohesive representation. It should be noted that older adults showed equivalent recognition for objects as young adults in Chalfonte and Johnson's study. Different from the paradigm of Chalfonte and Johnson's study that involved binding objects and their perceptual attributes, the present study involved binding objects and background scenes at a semantic level. The richer semantic content of background scenes might have allowed for stronger binding of information than Chalfonte and Johnson's stimuli. Considering that young adults have better associative memory than older adults, unbinding of features in a strongly bound representation might have a larger detrimental effect on memory for objects among young adults in comparison to older adults.

Lastly, as reported in Old and Naveh-Benjamin's (2008) meta-analysis on age-related declines in associative memory, there were larger age differences in associative memory tasks under intentional than under incidental encoding instructions. This is because older adults experience more difficulties establishing self-initiated processes for binding information, and hence do not benefit from intentional processing of information as in the case of young adults. The deficit in self-initiated processes in older adults has been linked to age-related declines in the frontal lobes, which are responsible for initiation and strategy formation. In the current study, although participants were not informed about the memory tests, 87.5% of the participants indicated on the background questionnaire that they were aware of the memory tests during encoding, which made encoding of this study largely intentional. Taken together, older adults' deficit in memory binding, especially in an intentional encoding task, acted as an advantage for them in memory for objects under unbinding. Young adults, on the other hand, bound objects and backgrounds more successfully than older adults, and therefore showed larger impairments in recognition for objects when contextual information was removed from the objects.

It might be puzzling that recognition for backgrounds did not differ across the two age groups in the same fashion as recognition for objects. The distinctiveness of the objects (i.e., the green colour) might make them prioritized as the focus of attention during encoding. This might be more relevant to older adults providing the evidence that older adults tend to engage in local processing (i.e., processing of focal information) in comparison to young adults (Oken, Kishiyama, Kaye, & Jones, 1999). Due to reduced cognitive resources in older adults, such as age-related declines in processing speed (e.g., Salthouse, 1996), they might not be able to process backgrounds fully or deeply, which were bigger in size and more spreading in the field of view than the objects. As a result, older adults' poor binding at encoding did not further benefit their subsequent memory for unbound backgrounds in comparison to young adults.

The finding that older adults showed better recognition for objects than young adults contradicts Gutchess and Park's (2009) finding. Gutchess and Park did not find any age difference in object recognition, albeit the same line drawing pictures were used in the two studies. It should be noted, however, that there are several differences in the design and stimuli between the two studies. First of all, the objects in the present study were in green colour, which were more outstanding and distinctive than the black objects in Gutchess and Park's study. Secondly, some of the pictures in Gutchess and Park's study contained more than one focal object. It is questionable which part of the picture participants paid attention to during encoding. For example, there were three women in one kitchen scene, whereas only one of the women was the object that appeared in the recognition task. If participants did not pay attention to the correct object, their recognition for that object would be impaired. This was corrected in the present study by highlighting the objects in green, such that participants could distinguish between the objects and backgrounds clearly at encoding. These differences in experimental design might have contributed to the disparity in findings between the two studies.

**The Influence of Picture Congruency on Recognition**

It was hypothesized that Chinese participants would show better recognition for images from incongruent pictures than images from congruent pictures. However, our results indicate that participants across cultures and age groups recognized more images from congruent pictures than images from incongruent pictures. The result contradicts with the finding that Chinese are more sensitive to incongruent pictures than Americans (Jenkins et al., 2010). Specifically, previous research has shown that Chinese participants showed greater adaptation to incongruent backgrounds than to congruent backgrounds in their right and left lateral occipital complexes (Jenkins et al., 2010), and that the effect did not appear among American participants. It should be noted that Jenkins et al.'s study was a neuroimaging (fMR-adaptation) study, and behavioural data were not collected. As a result, their study could not speak directly to the effect of congruency of pictures on picture recognition among East Asians.

Gutchess and Park (2009) did not find an effect of congruency on memory for objects under an unbinding manipulation. Nevertheless, in the third experiment of the same study, Gutchess and Park (2009) found that participants remembered more intact pictures (i.e., same object-background combination as pictures presented at encoding, in comparison to pictures with re-paired object and background) that were congruent at encoding than pictures that were incongruent at encoding. Although an unbinding manipulation was not employed, the finding of this experiment suggests that relatedness of objects and backgrounds at encoding have an impact on later recognition. Furthermore, as reviewed by Oliva and Torralba (2007), objects that are paired with congruent or familiar backgrounds are detected more precisely and encoded more quickly than objects with incongruent backgrounds. For instance, Davenport and Potter (2004) found that objects that were shown with consistent (i.e., congruent) backgrounds were identified more accurately than objects that were shown with inconsistent (i.e., incongruent) backgrounds. The same effect was true for backgrounds – backgrounds that were presented with consistent objects were identified more accurately than backgrounds paired with inconsistent objects. Some researchers have suggested that the effect of picture congruency on picture identification was due to an activation or priming of stored representations of the object and contextual scene (see Oliva & Torralba, 2007). For example, a contextual scene (e.g., a farm) might cue the viewer of certain objects that might appear on that scene (e.g., a cow, a chicken). When the target object is consistent with the viewer's presumption about the scene, identification of the object will be faster and more accurate.

**Interaction Effect of Age and Culture on Recognition**

One of the goals of this study was to examine the interaction effect of age and culture on memory under unbinding. The results of the study indicate a marginally significant interaction effect of age and culture. Specifically, Canadian older adults were better than Chinese older adults in the recognition (i.e., hit rates) of images. Moreover, there was also an unexpected trend for Canadian older adults to recognize more images than Canadian young adults. The superior recognition performance of Canadian older adults under unbinding could be explained by their tendency to encode objects and backgrounds separately as discrete entities. As aforementioned, Canadian participants recognized more isolated backgrounds than Chinese, and older adults in general recognized more isolated objects than young adults. These cultural and age differences were plausibly due to differences in cultural bias and age-related declines in binding objects and backgrounds together during encoding, which in turn impaired Chinese and young adults' memory for isolated images at recognition. On the one hand, Canadian older adults had better recognition for backgrounds than Chinese participants, presumably because of their more robust tendency to encode objects and backgrounds separately due to their accumulated cultural experience, and because unbinding at retrieval matches with their culturally preferred analytical processing style. On the other hand, they recognized more objects than young participants because of their age-related declines in binding objects and backgrounds together during encoding. It is speculated that analytical encoding of pictures is beneficial for later recognition of the images under unbinding. As a result, Canadian older adults showed the best recognition performance compared to the other three participant groups. That being said, it is important to note that Chinese older adults' overall recognition performance was similar to young adults from both cultures, which indicates that they were as successful as young adults in information binding. This supports the claim that the trajectory of cognitive aging may differ across cultures (e.g., Luszcz, 2006; Park & Gutchess, 2006; Park et al., 1999).

Last but not least, it is noteworthy that the effect of age appeared in both hit rates and recognition discriminability (*A*') for objects, whereas cultural difference in background accuracy was only found after false alarm rates were controlled for. This distinction is possibly due to the relatively intentional encoding of objects in comparison to the incidental encoding of backgrounds. As aforementioned, it is more cognitively challenging for older adults to engage in intentional, rather than incidental, memory binding tasks (Old & Naveh-Benjamin, 2008). The cognitive load under intentional processing, in addition to universal age-related declines in associative memory, made it difficult for older adults across cultures to engage in binding of objects and backgrounds during encoding. Consequently, older adults across the two cultures showed similar advantages in object recognition under unbinding. In contrast, the incidental encoding of backgrounds might require less cognitive resources than the relatively intentional encoding of objects, and as a result background processing allowed both young and older adults to employ their culturally favoured processing strategies. It is highly likely that participants used these strategies subconsciously, as their preferences were not reflected in our self-report measure. However, the exact underlying mechanisms are beyond the scope of this experiment and therefore could not be addressed.

The above speculation further suggests that the effect of age is more biologically dependent than the effect of culture, and is mainly expressed in effortful, resource demanding tasks. On the other hand, the effect of culture may be more dependent on experiences, and is more likely to show in spontaneous, or incidental, tasks. This speculation is in line with Park and colleagues' (1999) argument that cultural differences attenuate as tasks become more cognitively demanding, and these differences intensify as tasks become less effortful.

**Limitations and Future Directions**

There were several limitations of the present study. First of all, although participants' memory for pictures under unbinding was examined in this study, an inclusion of a memory binding task could further investigate the effect of unbinding on associative memory and how this effect varies with age and culture. Specifically, the binding task (whereby participants are asked to recognize pictures with intact or recombined objects and backgrounds) would demonstrate participants' baseline memory performance in remembering complex pictures, allowing researchers to directly compare participants' memory under unbinding with that under binding. This will inform researchers whether one age/cultural group (e.g., Chinese participants, young adults) is more affected by an unbinding manipulation at retrieval than another group of participants.

Second, objects in some of the picture stimuli might not be equally common across the two cultures. These picture stimuli were used with a goal to replicate Gutchess and Park's (2009) study. In comparison to Canadian participants, Chinese participants rated the congruency of the pictures more slowly and had lower agreements with the congruency of the pictures. However, this cultural difference might be due to Chinese' fixation on the relation between objects and backgrounds and their tendency to associate objects and backgrounds in a meaningful way. Moreover, Chinese participants performed as well as Canadian participants on recognition for objects, which indicates that there was no difficulty with encoding of pictures among Chinese participants. Also, removal of pictures with low congruency rating agreement did not affect the overall results of the study, and hence it is unlikely that cultural difference in background recognition was due to the stimuli of the study. Nevertheless, it is recommended to replicate the current findings in future studies with a set of stimuli involving culturally equivalent objects and background scenes. In addition, it is also optimal to use coloured naturalistic photographs as stimuli because naturalistic pictures have higher ecological value and may encourage deeper binding of images.

Third, the green colour of the objects might have biased participants' attention towards the objects during encoding, which in turn led to a higher recognition for objects than backgrounds. However, previous research has demonstrated that identification of objects is better than that of backgrounds, even when participants are deliberately asked to focus on either component of the picture (Davenport & Potter, 2004). Hence, the difference between object and background recognition is not surprising, and the emphasis on objects during encoding should not have affected the general results of the present study. That being said, coloured photographs can be used in future studies to reduce the difference in recognition for objects and backgrounds. It is important to note that objects were highlighted in green in the present study because some picture stimuli contained more than one object. Pictures in future study should therefore include only one focal object in each picture to make certain that participants pay attention to the correct feature.

Fourth, reaction times in the recognition tasks were not recorded. This is because participants were asked to indicate their confidence in their responses, which required them to move their left hand to the number keys on the top of the keyboard. Participants would then need to return their left index finger to the "z" key ("Yes" key) of the keyboard for the next trial, which would in turn affect their reaction time in the following trial. Future studies could include an interstimulus interval of a longer duration to allow sufficient time for participants to relocate their left index finger after making the confidence ratings.

Lastly, the results of this study do not speak to the neural basis of the mechanisms that underlie the age differences in object recognition and cultural differences in background recognition. It is speculated that these differences were due to age-related declines and cultural predisposition in binding during encoding. It is of interest to examine the underlying neural mechanisms during both encoding and retrieval using neuroimaging techniques, such as event-related potential (ERP) and fMRI measures. The hippocampus will be particularly important to investigate, because it has been shown to activate during binding of semantically related information (e.g., Goh et al., 2007; Henke et al., 1999; Sadeh et al., 2012). It has also been found that the hippocampus is more involved in memory binding, whereas the parahippocampal cortex and perirhinal cortex are involved in contextual and item processing respectively (e.g., Giovanello, Schnyer, & Verfaellie, 2004; Sadeh et al., 2012). Sadeh and colleagues (2012) also reported that these three brain regions engage in different pathways in recall and recognition of bound information. In particular, memory recall of bound information starts from context-related activity in the parahippocampal cortex, to activation of the hippocampus, to item-related activity in the perirhinal cortex. In contrast, recognition of bound information involves a reverse pathway, in which activation is initiated by activation of the perirhinal cortex, followed by activity in the hippocampus, and then finally activation of the parahippocampal cortex. That being said, future research could further explore age and cultural differences in hippocampal activation under unbinding.

## Conclusions and Implications

The purpose of this study was to examine age and cultural differences in associative memory under unbinding. To examine cultural differences, this study involved Chinese participants in Beijing and Canadian participants of European descent in Toronto. During encoding, young and older adults from the two cultures viewed complex pictures that each contained a focal object and a background scene. Participants then recognized these objects and backgrounds in isolation in subsequent memory tests. The results showed age and cultural differences in recognition under unbinding. Specifically, older adults outperformed young adults in recognition for objects, but this age difference became marginally significant after levels of depressive symptoms were controlled for. Second, Canadian participants were better than Chinese participants in recognition for backgrounds. The cultural effects only emerged after false alarm rates were controlled for. There was also an interesting interaction effect of age and culture, in which there was a trend for Canadian older adults to recognize more isolated images than the other groups of participants. The above age and cultural differences in memory was possibly due to dissimilarities among participants in the degree and strength of information binding during encoding. Finally, it was also found that images from congruent pictures were better recognized than images from incongruent pictures.

The findings of this study have far-reaching implications. To my knowledge, this is the first study that investigates both cultural and age differences in memory under unbinding, as well as in recognition for isolated unbound backgrounds. The findings further support age-related declines in associative memory and cultural differences in information processing styles. In addition, this study also provides insight into the interaction effect of age and culture on associative memory. Particularly, Chinese older adults showed equivalent performance as young adults across the two cultures, suggesting that age-related associative deficits might not be universal. In fact, culture-specific experiences or processing styles may serve as a protective factor against cognitive aging, and thus help individuals overcome processing impairments caused by biological declines. On the other hand, Canadian older adults' recognition was better than the other three groups of participants under unbinding, possibly due to poorer binding of objects and backgrounds during encoding. Given past findings that older adults can be trained to use associative strategies to facilitate associative memory performance (Naveh-Benjamin et al., 2007), it is speculated that older adults from the Western culture may benefit from learning to encode and associate information in a holistic way, whereas such training may not be necessary for East Asian older adults. That being said, findings of this study could serve as guidance for the acquisition of culture-specific strategies in associative memory through learning. The results could also be informative for the development of intervention programs that are tailored towards the needs of elderly with different cultural backgrounds.

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