Asian J Gerontol Geriatr 2007; 2: 93–8

Ageing effect on face recognition

ORIGINAL ARTICLE

KYY Ng[1] B Cog Sc, **KYL Hon**[2] BSc, MSc, **TMC Lee**[3] PhD

1 Laboratory of Neuropsychology, The University of Hong Kong, Hong Kong
2 School of Psychology, The University of Birmingham, United Kingdom
3 Institute of Clinical Neuropsychology, The University of Hong Kong and Maclehose Medical Rehabilitation Centre, Hong Kong

Correspondence to: Dr Tatia MC Lee, K610, Laboratory of Neuropsychology, The University of Hong Kong, Pokfulam Road, Hong Kong. E-mail: tmclee@hkusua.hku.hk

ABSTRACT

Objectives. To examine the differences in face memory between young and older adults.

Methods. The 46 healthy participants, 23 young (mean age, 21.8; standard deviation, 0.4 years) and 23 older (mean age, 66.4; standard deviation, 3.7 years) adults volunteered for this study. They were asked to learn and recognise unfamiliar faces in three recognition trials: after a single exposure, after four exposures, and after a half-hour delay.

Results. The findings indicated non-significant differences in recognition accuracy ($p>0.05$), though the performance of the young adults was superior. However, for reaction time, there was a significant group and condition interaction ($p=0.02$).

Conclusions. Compared to young adults, older adults may use a different processing route during face recognition in order to compensate for the decline in their cognitive abilities.

Key words: Aging/psychology; Face; Memory; Mental recall; Pattern recognition, visual

INTRODUCTION

Presumably, expertise in remembering faces may be superior in the elderly, since they have accumulated considerably more experience in this respect.[1-3] However, together with the evidence of the effect of ageing on cognitive abilities,[4-6] age-related deficits in remembering unfamiliar faces have been reported in elderly people.[7,8] Several cognitive developmental phenomena may account for age-related changes, if any, in face memory. According to the face-processing model of Young,[9] face recognition involves a decision-making system that weighs information from at least two retrieval processes. One signals the degree of resemblance between a face that is currently being examined and representations of faces in the memory, while the other accesses semantic information specifying the identity of a face, or contextual information about the circumstances of an encounter with that face, or both. While older and younger adults might employ both processes, it has been suggested that the elderly have a greater tendency to use the former process, and thus be less accurate in facial recognition. Furthermore, based on cognitive studies, one of the common explanations of the effect of ageing on face recognition is that it is related to the familiarity effect. Past research on the familiarity effect, also known as the resemblance hypothesis, indicates that elderly people rely more on familiarity as a basis for recognition decisions than do young adults.[3,10] Since faces are highly homogenous sets of stimuli having a high level of similarity, strong signals of resemblance between faces stored in the memory and face stimuli presented would increase the probability of false-alarm errors.[3] Therefore, older people are more susceptible to false-alarm errors in response to new faces compared to younger adults.[4] Bartlett and Leslie[11] have also suggested that ageing involves various processing slowdowns and inefficiencies, which lead to inferior memory abilities.[12]

Assuming normal ageing does have an impact on face memory, it remains unclear whether the impact is on the learning or the retrieval phases of the process,[3,12,13] or on both. Cohen and Faulkner[14] argued that adverse changes in the ability to remember faces could be due to the poorer retrieval of stored information, as older people seem to have difficulty in distinguishing between external memories and internal, self-generated memories, exhibiting more source confusion errors, and more frequently attributing actions to the wrong sources.

In this study we investigated the effect of ageing on face memory. Furthermore, we explored the age-related deficit in encoding the distinctiveness stimuli.[5,7] We speculated that older people would perform less well on the retrieval phases of the face-learning task.

METHODS

Participants

Forty-six healthy Chinese participants recruited from the community took part in the study; 23 were young adults (mean age, 21.8; standard deviation [SD], 0.4 years) and 23 older adults (mean age, 66.4; SD, 3.7 years). We were unable to match the education levels of our young and older participants, simply because it was very difficult to identify young adults who had received a very low level of education, because of the changing socio-economic climate in Hong Kong and the implementation of compulsory education.

Participants needing correctional lenses to view the stimuli wore their own glasses or contact lenses during the experiment. All were right-handed, as confirmed by the questions of the Lateral Dominance Test of Harris.[15] The Balloon Test[16] measuring the visual attention level was also used in screening the subjects.

The participants were of normal intelligence, estimated by their educational level and past or current occupations. Their visual attention and visual spatial perceptual abilities were screened using the Balloon Test[16] and the Hooper Visual Organization Test.[17] During a selection interview, participants were screened for a history of neurological or psychiatric illnesses. Informed consent was obtained from each subject.

Stimuli materials

The face-learning paradigm developed by Dade and Jones-Gotman[18] was used to compare the encoding process between young and older adults, as well as short- and long-term retention in patients with neuropathologies. All participants were presented with the same set of stimuli over several trials to reduce the susceptibility of individuals to fluctuations in their performance. The trials were followed by a half-hour delayed-recall recognition trial to determine whether retrieval differed between younger and older adults.

The face stimuli used in the experiment were black-and-white pictures of faces of young individuals, with clothes and hair cropped from the photos. Ears were also excluded, as some ears were hidden by hair. A Canon Zoom Browser S45 digital camera with resolution of 1024 x 768 pixels was used to take the photos. Photos were taken at a distance of 90 cm in a backlit room. The models were asked to maintain a half-smile, a natural and pleasant expression.

For the purpose of this study, only single-view photos were used. Although artificial, this approach simplified the experiments and was helpful in formulating theoretical concepts of face memory. There were 56 photos in total, consisting of 14 sets: 14 original photos and 42 altered images. Two sets were employed for the testing trials, and the remaining 12 sets for the face memory test. From each original face, three altered faces were created using digital imaging software (Adobe Photoshop 6.0), with each altered face differing from the original face by a combination of featural and configuration changes. For the former, the size of the eyebrows, eyes, nose, and mouth were modified with three levels of difficulty. For the configural changes, the distance between the eyes and the eyebrows was adjusted accordingly. Three distractors were created for each target face, increasing the difficulty and specificity of the tasks. Such increases in difficulty allow a true evaluation of face learning, differentiating it from mere guessing.

There were two kinds of trial, namely learning trials and recognition trials. Six original faces and six altered faces (three male and three female) were chosen to create the learning set. Consequently, each model had one face, either original or altered, as the

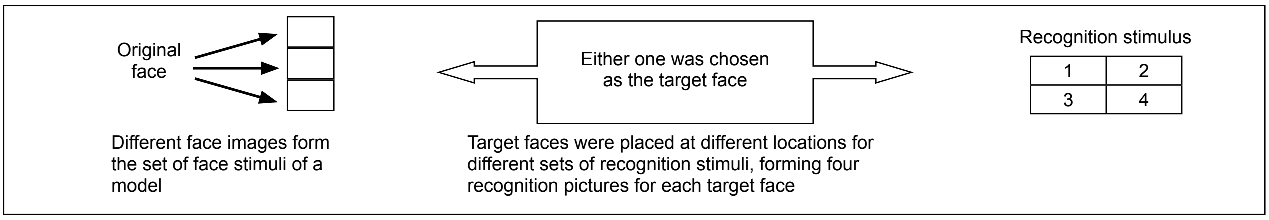

Figure 1. Schematic diagram of the stimulus

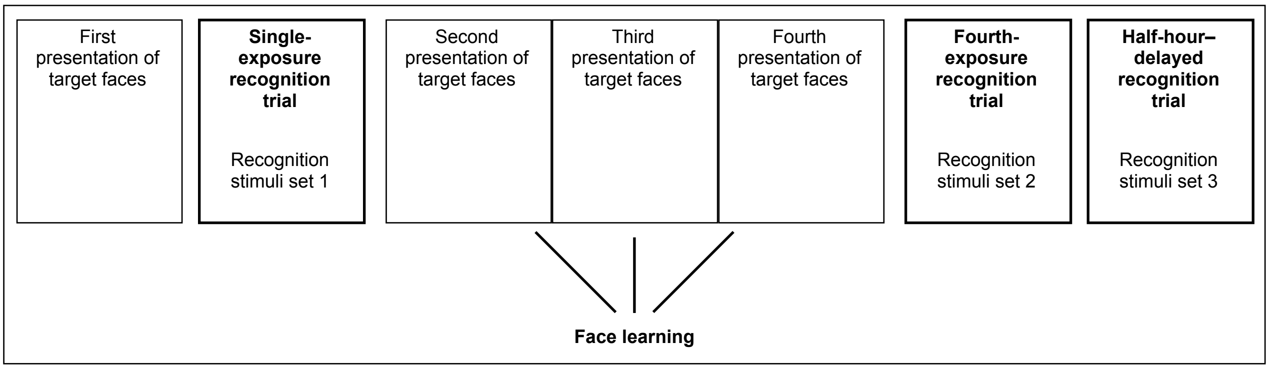

Figure 2. Schematic diagram of the stimulus

target face (12 cm x 14.5 cm).[18]

For each recognition trial, a four-face stimulus was created. The recognition stimuli were created using the target faces, with the remaining three faces of each model as the distractors. Four photos from each set were put together by minimising the margins, in a 2 x 2 format, to form a large picture (16 cm x 21 cm). Actual face sizes were controlled, so that the sizes of the recognition faces were similar to those of the target faces. If the size of the target faces in the learning trials differed too much from the face stimuli used in the recognition trials, the subjects might have to process a further step, such as transform the mental representation in their memory trace. The size of faces was therefore well-controlled. This minimised the possible transformation of the mental representation of the learnt target faces in the process of recognition. For better control of the effects of order and location, each photo had an equal chance of being placed in any one of the four different positions. This formed four recognition pictures for each target face. Thus there were 48 (12 x 4) recognition pictures. Different recognition pictures were used for each recognition test (**Fig 1**).

Procedures

The participants were tested individually. Photos of faces were presented in the middle of a computer screen (15″) using an IBM T20 notebook. A test trial was given before the experiment to familiarise the participants with the test materials. During the test trial, the experimenter gave instructions in order to inform the participants briefly of the aim and requirements of the test. A target face was then shown, and the participants were asked to study the facial features carefully. Two target photos and two recognition stimuli were presented.

At the beginning of the experiment, the subjects were informed that a set of faces would be shown, followed by a recognition test. Each participant underwent four presentations of the 12 target faces, with three recognition trials in the experiment (**Fig 2**). First, the 12 target faces were presented to the participants, followed by the single-exposure recognition (SER) trial. Three presentations of the 12 target faces were then presented, and a fourth-exposure recognition (FER) trial. Then, a half-hour–delayed recognition (DR) trial was carried out.[18]

During the four presentations of the 12 target faces, the participants were shown each target face one at a time for 4 seconds, with a 4-second inter-stimulus interval (during which the screen remained blank). For each recognition trial, the subjects observed 24 four-face photos, with each target face

Table
Group mean (standard deviation, SD) scores for the single-exposure recognition (SER), fourth-exposure recognition (FER), and half-hour–delayed recognition (DR) trials

	Group	Trials		
		SER	FER	DR
Mean (SD) reaction time (ms)	Older	4653.3 (906.7)	6465.2 (8770. 7)	4191.9 (990.7)
	Younger	4822.5 (597.2)	5378.4 (983.4)	4908.2 (860.0)
Accuracy (SD)	Older	9.0 (2.5)	10.65 (2.0)	8.83 (2.5)
	Younger	10.2 (2.1)	12.39 (2.8)	8.52 (2.2)

appearing twice in each recognition trial. This was a recognition task with four alternatives, in which the subjects had to choose which of the four faces was exactly the same as one of the 12 target faces. To indicate their choices, the participants pressed one of four buttons, 1 to 4, arranged according to the locations of the photos. If there was no response, the test stimuli would pass to the next trial after 8 seconds. Scores were obtained for each subject for the total number of correct responses (maximum=24; chance=6). Three test forms were created, with the faces in the recognition stimuli appearing at different locations in each form and in different orders.

Following the procedure employed in the Dade Face Learning Test,[18] a discrimination test was administered after the final recognition trial (DR). The test aimed to eliminate the possibility that subjects were actually incapable of discriminating between the target and the distractor faces. As a result, the face recognition test was able to reveal true memory deficits. There were 12 pairs of faces: six target-target pairs and six target-distractor pairs.[18] The subjects were asked to report verbally whether the two faces were the same or not. The total number of correct discriminations of the target photos (maximum=12; chance=6) was then scored.

Statistical analysis

The response accuracy and reaction times (RT) in all trials and both groups were recorded during the task. Descriptive statistics were calculated for age and education in years. As young adults (mean years of education, 15.13; SD, 10.14) have significantly higher education levels than older adults (mean years of education, 7.52; SD, 3.48) [$t(44)= -10.08$, $p<0.001$], education was a covariate factor entered in the analysis. A 2 x 3 mixed analysis of covariance (ANCOVA) design was therefore used, with age-group (older vs young) as a between-subjects variable and trials (SER vs FER vs DR) as within-subject variables. The significance level was set at $p\leq0.05$.

RESULTS

Reaction time

The means and SDs for the older and younger groups with respect to RT and accuracy in the three trials are presented in the **Table**. All effects are statistically significant at the 0.05 level.

The analysis of variance showed no significant main effect for the recognition conditions, Wilks' lambda=0.96, $F(2, 42)=0.98$, $p=0.38$, multivariate eta squared=0.045, or group factor, $F(1, 43)=0.73$, $p=0.40$. However, there was a significant interaction between conditions and groups, Wilks' lambda=0.838, $F(2, 42)=4.07$, $p=0.02$, multivariate eta squared=0.162. As shown in **Figure 3**, the older participants, relative to their younger-age peers, performed faster in the SER and DR conditions, but slower in the FER condition.

Accuracy

Analysis of variance showed no significant main effect for the different recognition conditions, Wilks' lambda=0.919, $F(2, 86)=2.435$, $p=0.094$, multivariate eta squared=0.081, group factor, $F(1, 43)=2.761$, $p=0.06$, or interaction between conditions and groups, Wilks' lambda=0.908, $F(2,86)=2.396$, $p=0.097$, multivariate eta squared=0.092.

DISCUSSION

The literature has suggested a possible effect of age on face memory. We tested this speculation on normal elderly people with no apparent cognitive

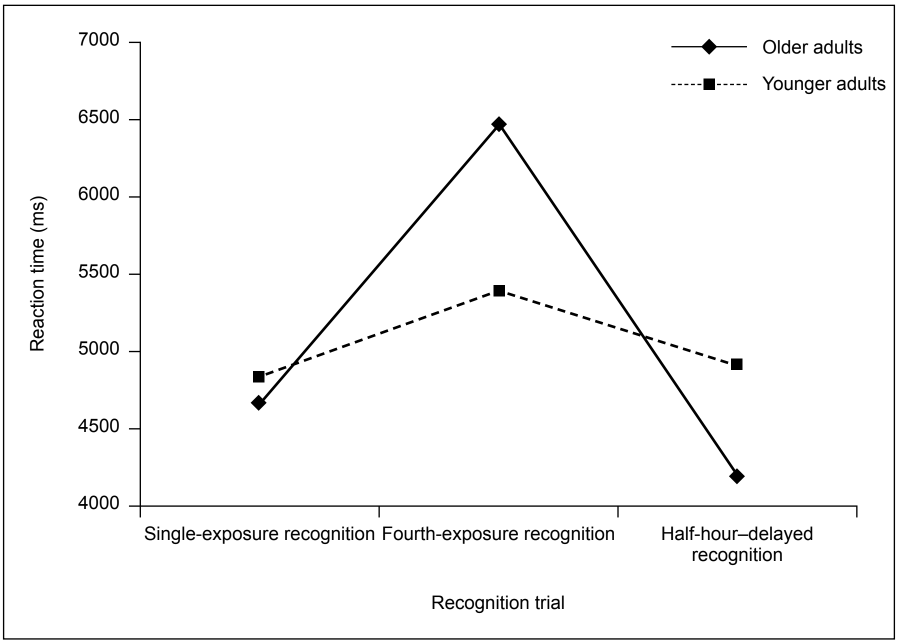

Figure 3. Face recognition memory scores

impairments. The findings of this study do not support this initial speculation and indicate that accuracy scores in the learning and retrieval phases of the face memory task as performed by our older subjects were not significantly lower than those of the younger adults. This suggests that there is no apparent ageing effect on the accuracy of face memory. The effect of learning on the accuracy of performance was observed in the FER trial, which suggested that both groups encoded more details with repetitive presentations of the face stimuli. Although there was a general trend towards deterioration in accuracy of performance in the learning phase, the older adults were able to catch up in the DR trial. This finding is similar to that of a recent study on ageing and prose memory, which found that, although older adults learned less efficiently, ageing did not correlate with the rate of forgetting.[19] Previous studies[11] have suggested that elderly people are less able to notice very slight changes in facial features. Older participants did therefore have less difficulty with memory tasks that did not require exact matching of details during retrieval.[12] Following this line of thought, correct identification of faces may only require the encoding of a few facial features.[20] Future research is required to verify this speculation.

Comparing the RT of the younger and the older participants, we found that older adults responded significantly slower on the FER. A plausible explanation for this is that the older adults needed a longer retrieval process during the learning phase. However, after the information was consolidated, the RT of the older adults were very similar to those of the younger adults, and so was their accuracy of performance. These findings suggest that the encoding process itself is the main factor that causes a high level of perceived resemblance, regardless of the task demand of the recognition trial. Previous research has suggested that working memory and attention resources degrade with normal ageing.[13] On the other hand, processes that are not attention-demanding do not decline with age.[12] The slowing of FER response in the older adults is consistent with the literature on ageing, which indicates that cognitive processes demanding substantial mental effort tend to degrade with age.

Park et al[21] reported that age-associated deficits in memory of pictures were only observed after a retention interval longer than the one adopted in our study. Unfortunately, due to the constraints of the testing time and availability of participants, we were unable to extend the DR trial to more than 30 minutes. Nonetheless, one study has suggested that there is no significant loss of performance in delayed recall.[22]

Our study could possibly have been extended to investigate the impact of time pressure on learning and responding, and explore the impact of emotional factors on the effect of ageing on face memory. Furthermore, studies of the episodic recognition of faces suggest that young subjects performed more successfully with young rather than older faces, while with elderly subjects the reverse was noted.[23] Imaging studies have revealed that recognising faces involves visual perceptual areas and areas that play an essential role in other cognitive and social functions, such as the anterior paracingulate cortex, the precuneus, and the amygdala.[24] Would different brain activation patterns be associated with the effect of ageing on face memory? Our findings seem to suggest that older people recognise accurately, once faces are successfully encoded. However, they require more time than that was given in our experimental set-up to learn the faces and make responses, as the effect of time pressure on their performance remains undetermined.

Despite the controls exercised in this study, differences in education levels between our young and older participants and possible variations in cognitive abilities among the participants could well have confounded our findings. Generalisation from the data we obtained should be made with caution.

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