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Increased Age Linked to Delayed Face Detection in Ambiguous Stimuli

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ABSTRACT

Previous research has identified correlations between individual differences, such as age, and perceptual processes. However, the specific roles of these factors in face and house detection and the categorization of ambiguous stimuli remain inadequately understood. To address this issue, we employed a face/house categorization task to investigate how participants of different ages perceive human agents versus non-natural objects amidst varying levels of visual noise (40%, 50%, 60%, and 70%). Our results revealed that older participants exhibit longer reaction times (RT) in face detection under low-noise, ambiguous conditions (40% noise) pointing toward a selective effect of age on face processing rather than on other object categories, such as houses.

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Introduction

Face and object recognition are essential components of human visual processing, relying on distinct cognitive and neural mechanisms. In typical face perception, the visual system is particularly sensitive to facial features, with evidence suggesting a strong holistic processing component that aids in rapid and accurate recognition, even under challenging conditions (Farah et al., 1998; Maurer et al., 2002). Object recognition, by contrast, tends to rely more heavily on feature-based processing (Diamond & Carey, 1986). Studies show that these perceptual abilities can vary with individual characteristics, such as age, sex, and cognitive processing speed, which can influence reaction time (RT) in visual categorization tasks (Alghamdi et al., 2021; Salthouse, 1996).

Age, in particular, has been shown to impact visual and cognitive processing, with older adults often experiencing slower RT in complex visual tasks due to factors like reduced neural efficiency and age-related changes in attentional control (Grady, 2012; Salthouse, 1996). While such findings are well-documented in general cognitive and perceptual tasks, the effects of age on ambiguous face versus object categorization, particularly in the presence of visual noise, are less explored. Given that aging may uniquely affect the perception of faces due to the specialized nature of face processing, this study aimed to examine how age influences RTs during face and house categorization tasks under varying noise levels.

In our study, participants completed a face/house categorization task with stimuli presented at different levels of visual noise (40%, 50%, 60%, and 70%) to assess their ability to differentiate faces from houses. This approach allowed us to analyze individual differences in categorization performance, with an emphasis on the effect of age on RT. We hypothesized that age would have a greater impact on RTs for face detection compared to house detection, given the well-documented age-related declines in face-specific perceptual processing (Fry et al., 2023; Germine et al., 2011; Slessor et al., 2013).

Method

Participants

A total of 82 healthy right-handed (Edinburgh Handedness Inventory score ranges: 40-100, consisting of 51 males and 31 females) students were selected for the study based on previous studies (Riekki et al., 2013; Van Elk, 2013; Van Elk et al., 2016). According to the self-report questionnaire, the participants had no history of psychosis, mental illnesses, acute or chronic diseases, neurological or personality problems, alcohol or drug abuse, or epilepsy. This study was conducted following the principles of the Declaration of Helsinki. All participants provided written informed consent before enrollment. The study used human faces as stimuli, adhering to ethical guidelines, and these faces as stimuli were previously used in another study (Heekeren et al., 2004).

Stimuli

Face/house categorization task. The stimulus was a set of pictures that were used in previous study (Heekeren et al., 2004, Narmashiri et al., 2023, Narmashiri et al., 2025). This set included 38 black and white houses and faces pictures (156 x 131 pixels). Different levels of noise in the stimulus are randomly added to it (Fig 1A). The visual noise levels of 40%, 50%, 60%, and 70% were selected for the stimulus of the present study. It has been determined that on average, 82% of participants answered correctly in low visual noise in a previous study (Heekeren et al., 2004). Based on this, by using a wide range of visual noise, it was shown that the greatest number of subjects would be able to correctly categorize most of the stimuli in low visual noise, while it becomes more difficult to recognize the stimuli as the visual noise level increases. Visual stimuli were presented for a duration of 3500 milliseconds, and participants were instructed to respond by pressing a button immediately following a mandatory stimulus onset. The interstimulus interval (ISI) was set to 1000 milliseconds (Fig 1B).

Procedure

The experiment was conducted in the psychology laboratory at the university with a laptop (Dell N5010) covered with a black cover. The participants sat in the experiment room and after obtaining their consent, the experimental task was explained. Participants were instructed that in this experiment they would see either a house or a face stimulus at different levels of visual noise (40%, 50%, 60%, and 70%). They were asked to press the number 1 on the keyboard when seeing house stimuli and the number 2 when seeing face stimuli (Fig 1B). It was emphasized that the participants should trust their first intuition and avoid prolonged thinking if they doubted the presented stimuli. This laptop was placed in front of the participants at a distance of about 60 cm. At the beginning of the experiment, the participants were allowed to do 10 practice attempts to familiarize themselves with the task. Each stimulus was presented for 3500 ms or until a response was given by the participant. The ISI was 1000 ms. In total, this experiment included 240 trials according to the following design: 4 levels of visual noise (40%, 50%, 60% and 70%), 2 categories of stimuli (face vs. house) and 30 repetitions in each category. Then the participants were asked to guess the target stimuli in different degrees of noise. The whole process of this experiment took 30-35 minutes.

Data analysis

A Smirnov-Kolmogorov test was utilized to assess the normality of the data, confirming its normal distribution. Following this, a Pearson correlation test was conducted to ascertain the association of age and noise levels on RT, independently for face and house trials. All statistical analyses in this study were conducted using MATLAB (version 2022, URL Link: https://www.mathworks.com/) and SPSS (version 27, URL link: https://www.ibm.com/spss), with the significance level set at $p < 0.05$.

Results

In our study examining participant performance in the face/house categorization task, we conducted a thorough analysis of participants' psychophysical functions with an emphasis on age, considering RT. Throughout the task, participants endeavored to differentiate between two stimuli—houses and faces—amidst varying levels of visual noise (40%, 50%, 60%, and 70%). The goal was to correctly identify whether the presented image was a face or a house (see Fig. 1A-B and the methods section).

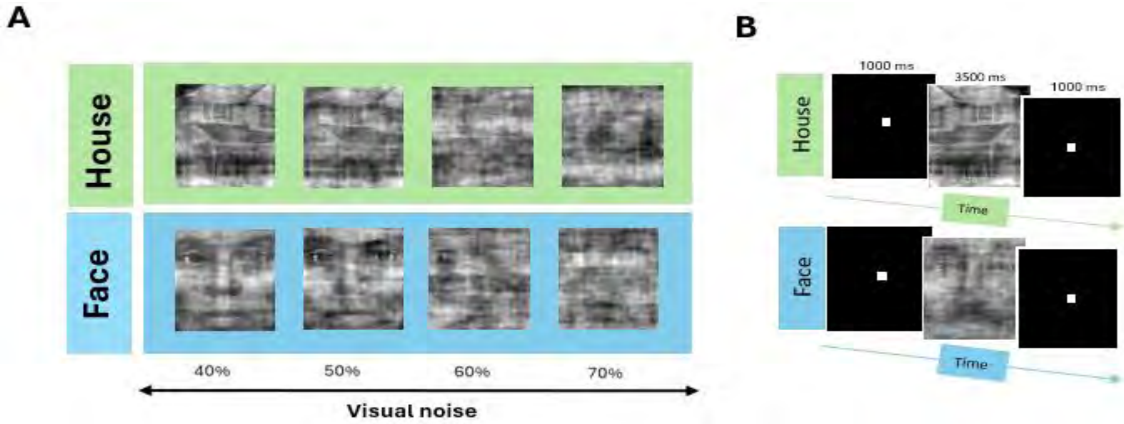

Figure 1. Face/House categorization paradigm and stimuli.
(A) Example stimuli used in the experiment represent houses (top) or faces (bottom) with increased levels of visual noise from left to right. B) The procedure involved stimulus (face or house trials) presentation lasting for 3500ms, after which subjects were instructed to press a button to register their response. Throughout the task, subjects were presented with stimuli featuring faces and houses, each with varying levels of visual noise. Their task was to identify and respond to these stimuli by pressing a specified key when they recognized either a house or a face stimulus. The duration between stimuli, known as the inter-stimulus interval (ISI), was configured to be 1000ms.

The results showed a positive correlation between RTs in face detection under ambiguous conditions (40% noise) and age ($r=.28$, $p=0.01$), indicating that increased age is associated with longer RTs for face detection in low-noise conditions (Fig 2A). This finding suggests that older participants may require more time to accurately process and categorize faces when perceptual ambiguity is present, potentially reflecting age-related changes in visual or cognitive processing specific to faces.

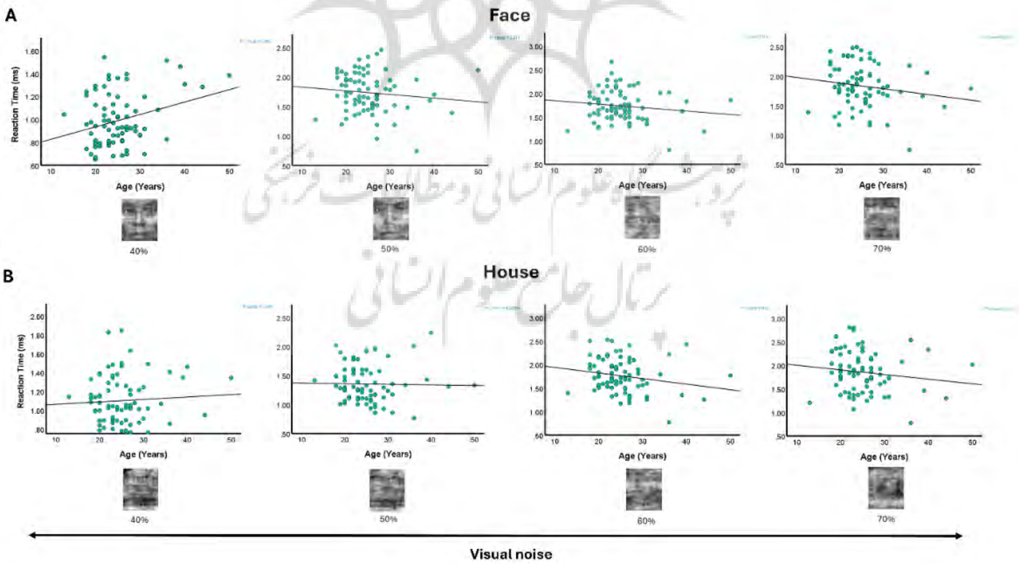

Figure 2. Correlation between face/house detection speed and age.
A) The y-axis illustrates RT (ms) for face trials, while the x-axis shows the age of participants. Each plot indicates different levels of visual noise (40%, 50%, 60%, and 70% from left to right), and the black line represents the regression line. B) The y-axis represents the RT (ms) for house trials, and the x axis denotes the age of participants. Each plot shows different levels of visual noise (40%, 50%, 60%, and 70% from left to right), and the regression line is represented by the black line.

In contrast, no significant correlation was found between RTs and age for house detection under ambiguous conditions across noise levels from 40% to 70% (Fig 2B). This lack of correlation in house trials suggests that age-related slowing in RTs may be selective for face stimuli under certain noise conditions and does not generalize to the detection of other stimuli, such as houses, even as noise increases. These findings highlight a potential age-related difference in sensitivity to ambiguity that is more pronounced in face detection tasks compared to house detection tasks.

Discussion and Conclusion

The current study investigated age-related differences in RTs in a face/house categorization task under varying levels of visual noise (40% to 70%). Our primary finding—that older participants exhibit longer RTs in face detection under low-noise, ambiguous conditions (40% noise)—points toward a selective effect of age on face processing rather than on other object categories, such as houses. This result aligns with existing literature suggesting that age-related declines in face processing speed and efficiency may be due to both cognitive and perceptual changes over time.

The observed correlation between age and RTs in face categorization, but not in house detection, suggests that faces require more specialized processing mechanisms, which are particularly susceptible to age-related decline. Faces are typically processed using holistic and configural strategies, which involve the integration of facial features into a cohesive percept (Richler et al., 2011). However, this ability to holistically integrate facial features may diminish with age, leading to slower and less efficient face categorization, especially when the face stimuli are ambiguous or partially obscured by noise. Previous Studies report similar findings, where older adults show slower RTs for faces, which may be due to a decline in configural processing abilities (Boutet & Faubert, 2006; Searcy & Bartlett, 1996).

Interestingly, the lack of a significant correlation between RTs and age in house detection suggests that the effect of age on processing efficiency is more pronounced for faces than for other object categories. Houses, unlike faces, are less likely to be processed holistically and instead may rely more on feature-based or analytical processing (Biederman, 1987; Grill-Spector & Kanwisher, 2005). Feature-based processing is generally less sensitive to aging than holistic processing, which could explain why older participants' RTs did not significantly increase with age for house stimuli under similar noise conditions.

The results also shed light on the impact of visual noise on categorization tasks. Visual noise increases task difficulty by obscuring distinguishing features, thereby requiring more attentional and perceptual resources to accurately identify the stimuli (Dosher & Lu, 2000). The finding that older adults have longer RTs in face detection at low noise levels (40%) but not in higher noise levels (50%-70%) might suggest that low to moderate noise conditions are particularly challenging for older participants, possibly because these levels increase ambiguity without fully obscuring facial features, demanding more effortful visual processing. This effect aligns with previous studies showing that age-related declines in visual processing are more pronounced under ambiguous or low-contrast conditions (Betts et al., 2007).

One possible interpretation of these findings is that age-related changes in neural processing may underlie the observed differences. The fusiform face area (FFA), a region in the ventral visual pathway crucial for face processing, exhibits reduced activation and functional connectivity in older adults compared to younger adults

(Grady et al., 2000; Park et al., 2010). This decline in neural efficiency may impair older adults' ability to quickly and accurately categorize faces, especially under conditions that require fine perceptual discriminations, such as low-noise ambiguous stimuli. In contrast, brain regions involved in processing non-face objects like houses may not exhibit the same degree of age-related decline, as they are less dependent on the FFA and more reliant on areas implicated in spatial and feature-based processing (Epstein & Kanwisher, 1998).

Overall, our findings suggest that age-related changes in face processing are specific to ambiguous conditions and do not extend to non-face objects, such as houses. This specificity aligns with prior research, which indicates that face perception relies on distinct neural and cognitive mechanisms. Mechanisms that may be more susceptible to aging compared to those involved in general object recognition. Future studies should explore how these age-related changes impact performance across different noise conditions, not only in healthy individuals but also in populations with conditions like schizophrenia, schizotypy, and paranormal experiences. Previous studies have shown correlations between these conditions and cognitive function (Narmashiri et al., 2024; Akbari et al,. 2024; Narmashiri et al., 2025; Narmashiri et al., 2023; Narmashiri et al., 2023; Narmashiri et al., 2022; Narmashiri et al., 2024; Narmashiri et al., 2020; Narmashiri et al., 2019; Sağdıç et al., 2024; Marosi et al., 2019; Bortolon et al., 2015; Narmashiri et al., 2015; Narmashiri et al., 2023; Narmashiri et al., 2025), highlighting the need for further investigation into the neural correlates that underlie the processing speed differences for face versus non-face stimuli.

Declarations

Author Contributions

MKH**:** Formal Analysis, Review & Editing. AN**:** Methodology, Formal Analysis, Writing – Original Draft Preparation, Review & Editing, Supervision. JH**:** Methodology, Formal Analysis, Review & Editing, Supervision.

Data Availability Statement

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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Ethical considerations

This study was conducted following the principles of the Declaration of Helsinki.

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Conflict of interest

The authors have no conflicts of interest to report.

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