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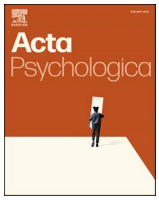

Relationship between face recognition ability and anxiety tendencies in healthy young individuals: A prosopagnosia index and state-trait anxiety inventory study

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ABSTRACT

Developmental prosopagnosia (DP) is a condition that indicates the inability to recognize individuals by their faces from birth, without any history of brain damage. The assessment of face recognition ability and diagnosis of DP involve the use of face tests such as the Cambridge Face Memory Test (CFMT) and the Cambridge Face Perception Test, along with self-reported measures like the 20-Item Prosopagnosia Index (PI20). Face recognition accuracy is affected by anxiety. However, previous studies on the relationship between face recognition ability and anxiety have not used the PI20 measure. This study aimed to investigate the relationship between self-reported measures of face recognition ability and anxiety tendencies among healthy young individuals for DP diagnosis and its implications. We used a face recognition test, involving the PI20, CFMT, Visual Perception Test for Agnosia–Famous Face Test (VPTA–FFT), and State-Trait Anxiety Inventory (STAI). We assessed the performance of 116 Japanese young adults (75 females, median age of 20.7 years, with a standard deviation of 1.2). Subsequently, we conducted a statistical analysis to examine the relationship between the outcomes of the face recognition tests and STAI scores using Pearson correlation analysis and single correlation coefficients. The results showed a positive correlation between state anxiety and PI20 ($r = 0.308$, $p = 0.007$), and a weak positive correlation was also observed between trait anxiety and PI20 ($r = 0.268$, $p = 0.04$). In contrast, there was no correlation between CFMT and VPTA–FFT with respect to STAI. The results of the hierarchical multiple regression analysis also suggested that the correlation between the performance on the PI20 (self-report) and objective measures of face recognition performance (the CFMT and the VPTA–FFT) are driven by differences in anxiety. This study is the first to explore the relationship between face recognition abilities and anxiety using the PI20 self-report measure. There are implications for future research on the diagnosis of DP and the relationship between anxiety and face recognition.

1. Introduction

Face recognition ability enables individuals to differentiate and identify faces, playing a crucial role in interpersonal recognition and everyday communication. Clinical and functional imaging studies have highlighted that brain lesions, particularly in regions such as the fusiform gyrus, can lead to face recognition impairment. In recent years, there has been a growing interest in the field of face recognition research regarding developmental prosopagnosia (DP). DP refers to a condition in which individuals experience lifelong impairments in face recognition despite possessing normal visual and intellectual capabilities since birth. Clinically, there is no indication of overt central nervous system disorders, and neuroimaging studies also reveal the absence of organic brain lesions (Bate & Tree, 2017; Behrmann & Avidan, 2005; Cook & Biotti, 2016; Duchaine & Nakayama, 2006a). Epidemiological studies in Europe and Asia have reported a prevalence rate of approximately 1.9 %–2.9 % of the population (Bowles et al., 2009; Kennerknecht et al., 2006; Kennerknecht et al., 2008). People with DP encounter challenges

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and psychosocial difficulties in their interpersonal interactions due to impaired face recognition (Yardley et al., 2008). Early diagnosis and support are crucial, especially before adulthood and entering the workforce.

Currently, diagnosing DP presents challenges due to the absence of established strict objective criteria or biological markers (Barton & Corrow, 2016; Susilo & Duchaine, 2013). Previous studies have revealed ambiguous criteria for diagnosing DP and differentiating it from conditions other than DP in face recognition tests (Bate & Tree, 2017; Dalrymple & Palermo, 2016). Dalrymple and Palermo (2016) provided guidelines that define DP as objectively poor performance on face memory tests and a subjective feeling of repeated face recognition failures in daily life. The authors emphasized the importance of using questionnaires and interviews to assess face recognition difficulties in daily life and highlighted the limitations of relying solely on questionnaires for DP diagnosis, as individuals with DP may lack accurate insight into their own face recognition abilities. They also emphasized the risk of diagnosing DP based on a single face test result and recommended the use of at least two face recognition tests as objective measures.

The Cambridge Face Memory Test (CFMT; Duchaine & Nakayama, 2006b) and the Cambridge Face Perception Test (Duchaine et al., 2007) are widely used as objective tests to assess face identification abilities. For assessing subjective face recognition ability, questionnaires such as the 20-Item Prosopagnosia Index (PI20; Shah, Gaule, et al., 2015) and the Hereditary Prosopagnosia Screening Scale (Kennerknecht et al., 2007) have been used. The PI20 comprises 20 items and has demonstrated a strong correlation with face recognition test results (Gray et al., 2017; Shah, Sowden, et al., 2015), rendering it a valuable tool for DP screening. In Japan, the Visual Perception Test for Agnosia–Famous Face Test (VPTA–FFT) version 2 (Japan Society for Higher Brain Dysfunction, 2015) has been standardized for the objective evaluation of face recognition and is widely used in clinical settings. The VPTA–FFT is a celebrities' facial features recognition test that uses photos of famous people, such as politicians and entertainers, as stimuli.

In the discussion of face recognition evaluation, recent studies suggest that anxiety can affect face recognition accuracy. Anxiety tendencies refer to an individual's inclination to experience anxiety across various situations, impacting cognitive functions such as attention, memory, and executive function. Previous research on the relationship between facial recognition ability and anxiety has employed anxiety assessment tools such as the State-Trait Anxiety Inventory (STAI, Spielberg et al., 1983) and the Social Interaction Anxiety Scale (Mattick & Clarke, 1998). Some studies indicate no direct correlation, while others report a connection between reduced face recognition ability and increased social anxiety (Bobak et al., 2016; Davis et al., 2011). In addition, studies on facial expression recognition and anxiety suggest that high-state anxiety can reduce the ability to recognize emotions from facial expressions (Attwood et al., 2017; Dyer et al., 2022).

However, no study has investigated the relationship between PI20, CFMT, VPTA–FFT, and anxiety. In previous research exploring the connection between anxiety and facial recognition ability, the STAI was used, but only a few studies conducted assessments for both state anxiety and trait anxiety (Attwood et al., 2017). In this study, to objectively assess both state anxiety and underlying trait characteristics of anxiety, we administered the Japanese version of STAI Form X (Spielberg, 2012), a self-reported scale.

Self-report methods have faced criticism for potentially generating inaccuracies in self-evaluation and for containing inherent biases in questionnaires, as individuals may have limited insight into their own abilities (Choi & Pak, 2005). Given the inherent nature of self-report methods, our hypothesis suggests that PI20 might be influenced by individual anxiety tendencies and could exhibit associations with both state anxiety and trait anxiety. The study aims to examine the correlation between face recognition ability and anxiety in young, healthy individuals using PI20, a subjective test, along with objective tests CFMT and VPTA–FFT, as well as STAI. By exploring this complex relationship, we emphasize the importance of considering anxiety tendencies when assessing face recognition ability in young adults. These findings could carry implications for the diagnosis of neurodevelopmental disorders, including prosopagnosia.

2. Materials and methods

2.1. Participants

A total of 117 undergraduate students from the Niigata University of Health and Welfare willingly participated in the study. All participants were Japanese and had been born and raised primarily within Japan. Following the initial recruitment, one individual was diagnosed with a mental disorder, resulting in a dataset comprising 116 participants (75 females and 41 males), with a mean age of 20.68 years and a standard deviation (SD) of 1.15. The participants were not selected on the basis of their face recognition ability and were simply recruited on a voluntary basis. None of the participants reported a history of neurological diseases, head injuries, and/or other medical conditions that might affect their speech-language performance. In addition, none of them showed any visual deficits or hearing disabilities. Written informed consent was obtained from all participants for inclusion in the experiments.

2.2. Neuropsychological test

2.2.1. Subjective face recognition test—PI20 questionnaire

As a subjective evaluation of facial feature recognition, we implemented the PI20 questionnaire (Shah, Gaule, et al., 2015) for the subjective judgment of face recognition. The Japanese version of PI20 is a Japanese translation of the original version, which was checked by a native English speaker. PI20 comprises 20 question items on face recognition. Each item is answered on a 5-point scale as to how the item concerned applies to the individual concerned from 1 (“I absolutely agree”) to 5 (“I absolutely disagree”). Item numbers 8, 9, 13, 17, and 19 are reverse-scaled items. The higher the total score, the stronger the DP tendency, and the reference value is 65.

2.2.2. Objective face recognition tests—CFMT and VPTA–FFT

As objective measures of face recognition ability, we used the CFMT (Duchaine & Nakayama, 2006a) to measure the ability to recognize face of unfamiliar people and the VPTA–FFT (Japan Society for Higher Brain Dysfunction, 2015) to examine the ability to recognize the face of famous people. The CFMT is a three-alternative forced choice task. The facial stimuli are all white males with neutral expressions. Images of faces viewed from a left diagonal direction, frontal view, and right diagonal direction are used. The head is not included, and only parts of the face are cropped. There are three types of tasks. Stage 1 is a task in which each participant learns the facial images of six target people and then selects the face learned. In Stage 2, the participants learn and reconfirm the faces of six target people simultaneously. For three facial stimuli that are presented at the time of recognition, the degree of difficulty is adjusted by trial using contrasting and face direction. In Stage 3, the participants relearn the faces of the same six people used in Stage 2 and recognition is performed from images with the noise applied at different levels of difficulty. Task one comprises a total of 18 trials, task two 30 trials, and task three 24 trials, amounting to a total of 72 trials. The CFMT is packaged as a Java program and recorded automatically from the experiment instruction until measurement of the response. The participants perform the tasks at their own pace. The test takes 10–15 min to complete. The task outcome is the total number of correctly identified target faces. In this test, the reference value, mean, and SD are presented, with a full score of 72 points, and the mean score for healthy individuals is 58 points, with an SD of 7.34 points and mean − 2SD of 43.3.

The VPTA–FFT is a famous face identification test. Twelve famous male and seven female faces were used as stimuli, and two types of face

photographs were employed. One is the face pattern with only the outline of the face, omitting the ears and hair (without hair) to exclude the impact of hints from information such as hair type and the head pattern (with hair). When creating the stimuli, authorized photographs of famous individuals were adjusted to ensure natural lighting and contours, and elements that could aid in facial identification, such as moles, were removed. The presented images were organized in booklet form and printed in B5 size (182 mm × 257 mm). There are three types of tasks, including the naming task that requires calling out the name, the instruction task that involves selecting the photo corresponding to a name from six options, and the recognition task in which a person's name written down is matched to a face photo. These tasks are conducted in the order of facial patterns (without hair) and head patterns (with hair). The procedures and scoring methods for each task are as follows.

For the first naming task, participants were given the following instructions before being shown the images: "You will see pictures of famous people's faces. Please provide their names. If you cannot recall their names, describe who they are or what they are known for." Subsequently, the images were presented individually, and participants were asked, "Who is this person?" Their responses were recorded. Even if they provided only the first or last name, it was considered a correct response. In cases where information was insufficient, participants were prompted with questions like, "Do you have any additional information about this person?" to assist in identification. If there was no response within 10 s, the examiner inquired about familiarity and records it in the designated section. Scoring was as follows: an immediate correct answer within 10 s scored 0 points, a delayed correct answer within 11–30 s scored 1 point, and incorrect answers or responses of "I don't know" scored 2 points.

In the second Pointing task, participants were given the following instructions before being shown the images: "On one page, there are four photographs of people's faces. I will say a name, and you should indicate the person I referred to." Then, the images were shown, and participants were asked individually to provide their responses and recorded them. Scoring was as follows: an immediate correct answer within 7 s earned 0 points, a delayed correct answer within 8–30 s scored 1 point, and incorrect answers, responses of "I don't know," or no response earned 2 points.

In the third name recognition task, participants were provided the following instructions before being presented with the images: "Along with facial images, there are names written for four people. Please select the name of the person shown in the photograph." Then, the images were displayed, and participants were asked, "Which name in this list corresponds to this person?" Their responses were recorded. If necessary, the examiner might read out the names. Scoring was as follows: a correct answer scored 0 points, while incorrect response, "I don't know" answers, or no response earned 1 point.

In summary, for all tasks, an immediate correct response yielded a total score of 0 points, meaning a lower score indicated better performance and higher scores indicated a greater number of incorrect responses.

2.2.3. Anxiety questionnaire—STAI

The STAI (STAI, Spielberg et al., 1983) is a widely used test to measure state and trait anxiety in both general and clinical settings. The STAI comprises 20 items for the trait anxiety scale and 20 items for the state anxiety scale. Each item is judged using a four-point scale of "not at all," "somewhat," "quite," and "absolutely," with a minimum of 20 points and a maximum of 80 points. The state anxiety pertains to the current emotional state and reflects the intensity of anxiety at the time of measurement; it changes from moment to moment. By contrast, trait anxiety reflects the underlying personality traits prone to anxiety. The higher the score in both, the stronger the tendency toward anxiety.

2.3. Statistical analysis

The reliability of PI20, STAI-S, and STAI-T data was calculated using Cronbach's alphas. We conducted a partial correlation analysis with Bonferroni correction between the PI20 score and the VPTA–FFT version 2 score, as well as the CFMT accuracy, which measures face recognition ability. Sex was used as a confounding factor. Next, we calculated the single correlation coefficient for the relationship between STAI state anxiety and trait anxiety with respect to PI20, VPTA–FFT, and CFMT scores. Furthermore, we calculated the single correlation coefficient to determine the association between excluded PI20 scores (excluding two items, Q11 and Q16,[1] which are thought to be particularly influenced by anxiety) and STAI-S and T scores. Hierarchical multiple regression was used to assess the hypothesis that the PI20 (self-report) performance may not depend on objective face recognition abilities but rather on anxiety. The dependent variable was set as PI20 scores, and the gender of demographic characteristics was initially entered as a control variable. Next, CFMT and VPTA–FFT scores, known to influence PI20, were entered as predictor variables. The influence of the two variables (i.e., STAI-S and STAI-T scores) was investigated by systematically adding these variables to the model. The normality of the data in each test was examined using the Shapiro–Wilk test. The significance level was set to <5 %. All statistical analyses were conducted using IBM SPSS Statistics 24.

3. Results

3.1. Neuropsychological test results

Table 1 summarizes the neuropsychological status for all participants.

3.1.1. PI20 scores and distribution

PI20 showed high internal consistency (Cronbach's $\alpha = 0.892$). The mean value of the PI20 was 46.34 (SD = 11.45), and its distribution did not significantly differ from the normal distribution ($p = 0.077$) (Fig. 1A). In PI20, DP was suspected at scores of ≥65, with scores of

Table 1
Neuropsychological status of the participants.

		Cutoff
Age, years	20.68 (1.15)	
Sex (female/male)	75/41	
Education, years	13.99 (0.92)	
Face recognition test		
PI20	46.34 (11.45)	≥65
Prevalence	6	65–74 (mild)
	1	75–84 (moderate)
	1	85–100 (severe)
CFMT total score	53.30 (6.96)	(cutoff 43.3)
VPTA–FFT total score	11.66 (10.90)	
Questionnaire test on anxiety		
STAI-S	41.60 (8.23)	46.8 (8.49)
STAI-T	49.04 (9.76)	48.3 (8.30)

The values in the second columns indicate the mean (standard deviation).
PI20: Japanese version of the 20-Item Prosopagnosia Index, CFMT: Cambridge Face Memory Test,
VPTA–FFT: Visual Perception Test for Agnosia–Famous Face Test version 2,
STAI: State-Trait Anxiety Inventory, STAI-S: State anxiety, STAI-T: Trait anxiety.

[1] Q11: "Anxiety about face recognition has led me to avoid certain social or professional situations," Q16: "I feel like I frequently offend people by not recoglnizing who they are" (Shah, Gaule, et al., 2015; Shah, Sowden, et al., 2015).

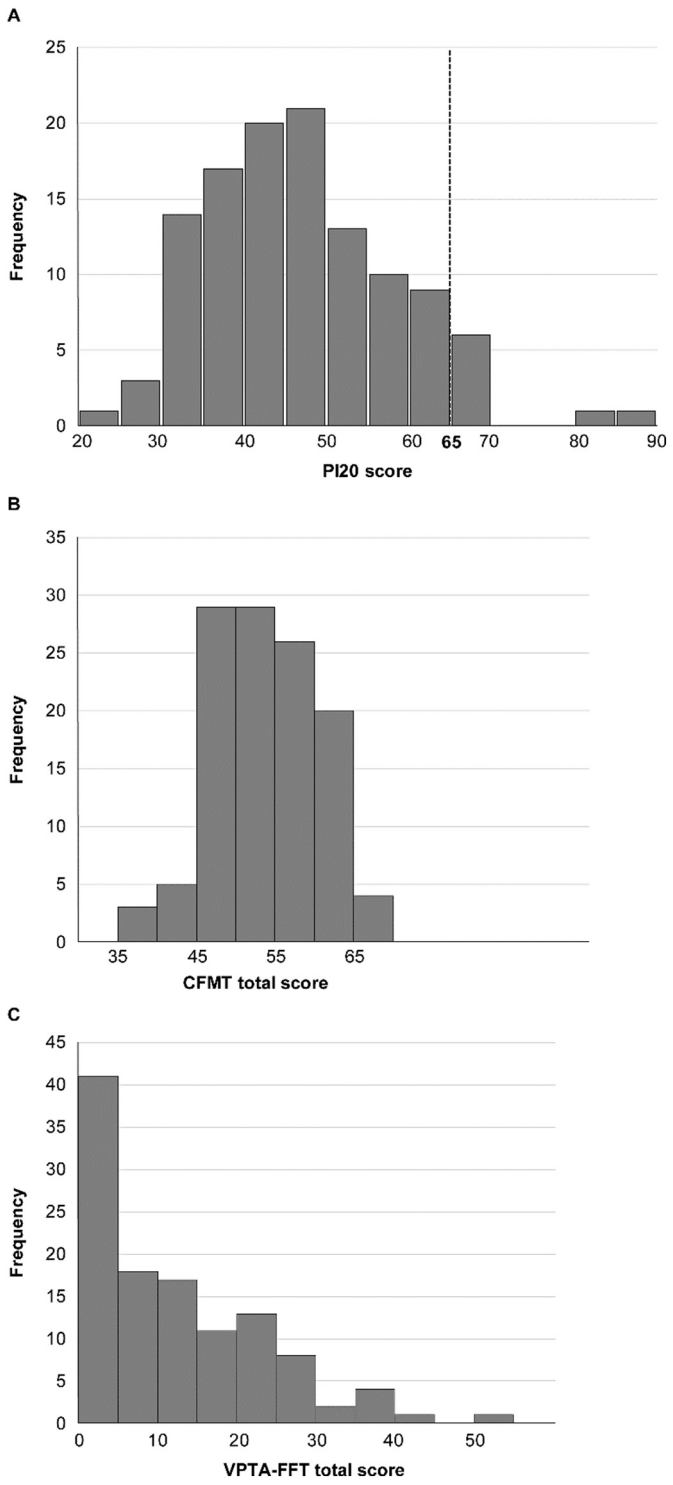

Fig. 1. A. Distribution diagram showing the total scores for the 20-Item Prosopagnosia Index (PI20)
B. Distribution diagram showing the total scores for the Cambridge Face Memory Test (CFMT)
C. Distribution diagram showing the total scores for the Visual Perception Test for Agnosia–Famous Face Test version 2.

65–74 indicating mild disturbance, 75–84 indicating moderate disturbance, and ≥ 85 indicating severe disturbance (Shah, Gaule, et al., 2015). In the present study, six individuals scored 65–74 (mild), one individual scored 75–84 (moderate), and one individual scored ≥85 (severe), i.e., in PI20, DP was suspected in eight individuals.

3.1.2. CFMT and VPTA–FFT scores and distribution

The mean total score of the CFMT was 53.3 (SD = 6.96), and the distribution did not significantly differ from the normal distribution ($p = 0.199$) (Fig. 1B). The total score for VPTA–FFT had a mean of 11.66 (SD = 10.90) (Fig. 1C).

3.1.3. STAI results and distribution

STAI-S and T showed high internal consistency (Cronbach's α = 0.891 and 0.895, respectively). In the STAI results, the mean state anxiety score was 41.6 (SD = 8.23), and the distribution did not significantly differ from the normal distribution ($p = 0.071$). The mean trait anxiety score was 49.04 (SD = 9.76), and the distribution did not differ significantly from the normal distribution ($p = 0.439$) (Fig. 2A–B).

3.2. Results of the correlation analysis

The results for the correlation between objective face recognition tests were as follows: There was a significant correlation between VPTA–FFT version 2 total score and PI20 score ($r = 0.266$, $p = 0.04$), a significant negative correlation between CFMT total score and PI20 score ($r = -0.280$, $p = 0.02$), and a significant negative correlation between VPTA–FFT version 2 total score and CFMT total score ($r = -0.356$, $p < 0.001$).

With respect to the relationship between STAI and face recognition tests, there was a significant correlation between STAI state anxiety scores and PI20 scores ($r = 0.308$, $p = 0.007$) (Fig. 3A). The black horizontal line indicates the cutoff value for PI20 and the dotted vertical line represents the cutoff value for the STAI-S score. The individuals represented within the gray circle are those with high scores for state anxiety.

There was a significant correlation between PI20 scores and trait anxiety scores ($r = 0.268$, $p = 0.040$) (Fig. 3B). The black horizontal line indicates the cutoff value for PI20 and the dotted vertical line represents the cutoff value for the STAI-T score. Individuals represented within the gray circle are those with high scores for trait anxiety. There was no significant correlation between STAI and CFMT and between STAI and VPTA–FFT.

Regarding the relationship between the scores, excluding two items (Q11, 16) from PI20 and STAI, there was a significant correlation between the 18-item PI20 and state anxiety scores ($r = 0.329$, $p < 0.0001$), as well as a significant correlation between this PI20 score and trait anxiety score ($r = 0.260$, $p = 0.005$).

In PI20, of the eight individuals with scores >65, which was the reference value for DP, four individuals had high anxiety scores, i.e., the scores exceeded the mean value +2SD of the participants as the STAI reference value. Of these four individuals, two had a high score for state anxiety (Fig. 3A) and three had high scores for trait anxiety (Fig. 3B).

The performance comparison of various examinations for the eight cases (Cases 1–8) suspected of having DP with a PI20 score of 65 or higher is shown in Table 2. Four of the high-scoring individuals in PI20 had normal results in two objective face tests. Among them, one individual had high scores in both state anxiety and trait anxiety (Case 3), and another was a high trait anxiety individual (Case 4). Case 6, who scored >1 SD below the mean on the CFMT with a normal FFT score, was a high-state anxiety individual. By contrast, Case 2 and Case 5, which showed abnormalities in two objective face tests, did not exhibit tendencies of both state anxiety and trait anxiety.

3.3. Consequences of anxiety prediction

A hierarchical multiple regression analysis was conducted to examine the independent influence of sex, VPTA–FFT, CFMT, STAI-S, and STAI-T. The Durbin–Watson coefficient of the final model was 1.993. The total R^2 of the variables of the regression model was 22.4 %, and the F value of the regression model was 6.337, which was significant at the level of significance probability ($p < 0.001$).

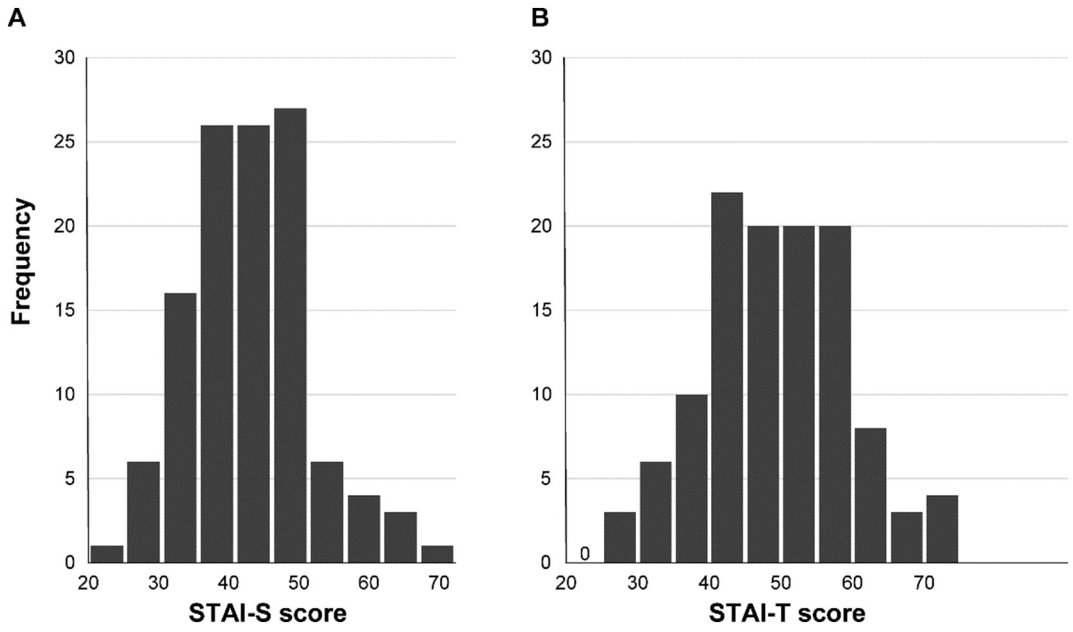

Fig. 2. A. Distribution diagram showing the total scores for the State Anxiety Inventory (STAI-S)
B. Distribution diagram showing the total scores for the Trait Anxiety Inventory (STAI-T).

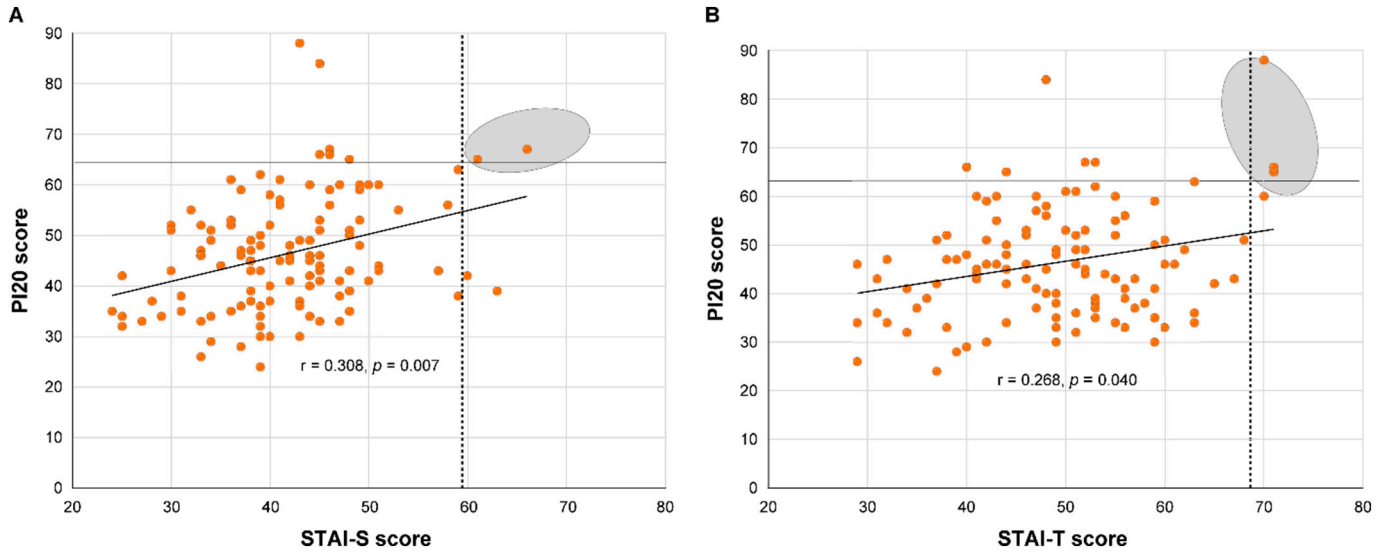

Fig. 3. A. Scatterplots illustrating the relationship between the scores for the 20-Item Prosopagnosia Index (PI20) and that for the State Anxiety Inventory (STAI-S).
B. Relationship between the scores for the 20-Item Prosopagnosia Index (PI20) and that for the Trait Anxiety Inventory (STAI-T).

The results shown in Table 2 indicated that CFMT, VPTA–FFT, and STAI-S significantly impacted PI20 prediction. However, sex and STAI-T did not influence the prediction. CFMT was negatively associated with PI20 prediction ($\beta = -0.193$, $p = 0.03$). PI20 was positively correlated with VPTA–FFT ($\beta = 0.189$, $p = 0.03$) and STAI-S ($\beta = 0.256$, $p = 0.007$). Among the independent variables, the explanatory amount of STAI-S was the largest.

4. Discussion

This study aimed to examine the relationship between face recognition ability and anxiety tendencies using both objective face tests and self-reported face recognition assessments. This study is the first to investigate the relationship between face recognition abilities and anxiety, utilizing the PI20 and STAI. Our primary new findings are the significant relationship between state anxiety, trait anxiety, and PI20; this suggests that the results of the self-recognition face test, PI20, are influenced not only by actual face recognition ability but also by psychological anxiety.

Several previous studies have investigated the relationship between face recognition ability and trait anxiety (Bobak et al., 2016; Davis et al., 2011). Consistent with these preceding studies, our study demonstrated that no correlations were observed between objective face recognition tests like CFMT or VPTA and trait anxiety. Additionally, the results of this study indicate no association between face recognition tests and state anxiety. The absence of association between trait anxiety and the CFMT and VPTA–FFT suggests that the psychological state and personality traits during the testing did not influence the inherent face recognition abilities.

In contrast, concerning the previously unexplored relationship

Table 2
Comparison of the scores of subjects suspected of Developmental Prosopagnosia (DP) in either the 2-item prosopagnosia index (PI20), State Anxiety Inventory (STAI-S), Trait Anxiety Inventory (STAI-T), Cambridge Face Memory Test (CFMT), or Visual Perception Test for Agnosia–Famous face test version 2nd (VPTA–FFT ver.2).

Case	Age/gender	PI-20	STAI-S	STAI-T	CFMT	VPTA–FFT
1	19F	67*	46	53	51	5
2	18F	66*	46	40	35**	36**
3	20F	65*	61**	71**	60	8
4	20 M	66*	45	71**	55	5
5	21F	84***	45	48	45*	36**
6	21F	67*	66**	52	45*	0
7	21F	65*	48	44	52	10
8	21 M	88***	43	70**	47	33*

Asterisks denote: single (*), differs from participants mean 1 SD; double (**), differs from participants mean 2 SD; triple (***), differs from participants mean 3 SD.

between PI20 and anxiety, this study's findings revealed a correlation between the two. The results of the regression analysis further substantiated the association between PI20 and state anxiety. Notably, individuals with higher PI20 scores tended to have higher state anxiety, suggesting that high PI20 scores might not be related to actual objective facial recognition ability. In simpler terms, individuals with high-state anxiety might perceive their own facial recognition ability as lower even if their actual ability to recognize faces remains within the normal range.

In the realm of face perception research, there has been a sustained fascination with the dependability of self-reported face recognition abilities (Bobak et al., 2016; Bowles et al., 2009; Kennerknecht et al., 2006; Shah, Sowden, et al., 2015). In psychological experiments targeting university students, there have been reports that self-perceived abilities to recognize unfamiliar faces do not align with actual face recognition test performance (Bindemann et al., 2014). In survey studies involving university students, it has also been shown that people have modest insights into their own face recognition abilities (Matsuyoshi & Watanabe, 2021).

DeGuts et al. (2023) investigated the correlation between objective and subjective face recognition using a large-scale web-based sample covering a wide age range (10–70 years, $N = 4143$) and revealed that awareness of face recognition peaked in the early to mid-20s, remained relatively stable from the 20s to the 40s, and declined from the 50s to the 60s. Subjective versus objective face recognition bias measurements indicated that participants aged 10–18 and 51–70 years tended to overestimate their own face recognition abilities compared to those aged 19–50 years. Additionally, more females tended to underestimate their face recognition abilities than males. These results indicate the possibility of biases in self-awareness of face recognition based on age and gender. Due to the potential instability in self-awareness of face recognition ability among university students aged 18–22 years, it is important to consider age and gender while assessing face recognition ability through self-report measures.

Furthermore, in DP, unlike acquired prosopagnosia following cerebrovascular diseases, individuals may have poor face recognition abilities from early childhood, leading to the possibility that they are not aware of their own difficulties in face recognition. DP can also have a genetic basis, and anomalies within the family may go unnoticed.

Therefore, it can be difficult to properly evaluate one's face recognition ability based only on a self-reported assessment based on the questionnaire. In the guidelines of Dalrymple and Palermo (2016), it has been proposed that when the face recognition test outcomes are within the normal range despite subjectively noticing problems in daily life in the questionnaire, such instances can be excluded from DP. In the present study, despite CFMT and VPTA–FFT falling within the normal range, four individuals recorded PI20 scores >65. Among them, two were classified as highly anxious. For these participants, individual interviews may be conducted to examine daily life issues thoroughly, and continuous follow-up on anxiety states may also be necessary.

Next, another hypothesis, the impact of secondary anxiety arising from mild face recognition difficulties, should be considered. Namely, it is necessary to discuss the possibility that anxiety arises secondarily from mild face recognition difficulties, contrary to the influence of underlying anxiety characteristics on self-assessment scale scores. As a result, we need to explore the potential association between PI20 and STAI.

DeGutis et al. (2023) focus on mild DP with subjective face recognition complaints, with performance worse than one SD below the normative mean on multiple face tests. They inferred from the large-scale survey results that face recognition difficulties lie on a continuous spectrum rather than representing a discrete population DP. They indicated the existence of a continuous spectrum of facial recognition impairments, highlighting its similarities with several developmental and neurological disorders, including autism and Alzheimer's disease. Using mild neurocognitive criteria of DSM-5 to their large web-based sample using a z-score approach, they found that DP prevalence rate was 3.08 %, with 2.15 % having mild DP and 0.93 % having major DP.

In a recent study by Burns et al. (2022), 56 % of individuals who believe they have prosopagnosia did not meet the diagnostic criteria commonly used for DP. They studied 61 individuals with self-reported lifelong difficulty with faces with either impaired CFMT scores (z-score < -2, so-called “Classical DPs”) or unimpaired CFMT scores (so-called “Excluded DPs” because they are routinely excluded from DP studies). They found that the excluded case also exhibited face perception and memory impairments that were roughly one SD below neurotypical norms, indicating the presence of objective problems. As a result, they suggest that a more lenient criterion should be adopted in diagnosing DP.

State anxiety refers to the subjective or conscious sense of tension and apprehension about how one perceives a situation or experiences stress, influenced by the placed circumstances or stressors (Spielberg, 2012). Whether external stimuli evoke a state anxiety response depends on whether the stimulus is perceived as threatening (Koga, 1980). Individuals with mild face recognition impairments may interpret face tests as threats due to social communication difficulties arising from face recognition impairment. As a result, state anxiety scores may be elevated, potentially correlating with PI20 scores.

While not exhibiting clear face recognition disorders based on traditional scale criteria, university students with mild face recognition impairments may face difficulties in real-world interpersonal relationships, potentially influencing trait anxiety and state anxiety. In this study, one participant with high-state anxiety showed a high score on PI20 and exhibited mild face recognition impairment in the objective face test, CFMT. It might be necessary to consider the impact of social anxiety related to mild facial recognition impairments on self-reported facial recognition disorders without rigidly adhering to traditional scale criteria and without excluding individuals with mild face recognition impairments.

The observed correlations between PI20 scores and state anxiety, could offer valuable insights for assessing face recognition abilities and diagnosing DP. PI20 is a useful tool for evaluating face recognition ability, capturing both prosopagnosia-related challenges in daily life and distinctive strategies employed in face recognition. However, since questionnaire scores rely on respondents' self-evaluation, factors beyond face recognition ability, such as respondents' anxiety traits and interpersonal discomfort, could also influence the results. Therefore, a single self-reported face recognition test is insufficient for evaluating face recognition ability and diagnosing DP in young individuals. When diagnosing DP, subjective indicators of facial feature recognition impairment should be performed together with objective facial feature recognition tests and considered the presence and extent of anxiety tendencies.

However, our results cannot rule out the possibility of being influenced by the sample size and potential biases in participant selection. Given that our participants were restricted to Japanese university students, there will be a discussion regarding the extent to which these findings can be generalized to a broader population of younger individuals. Furthermore, the relationship between facial recognition abilities and social anxiety was not considered in this study. Therefore, further verification is necessary for future research.

Several limitations of this study should be noted. First, the participant sample of the present study comprised healthy university students, and it did not include individuals diagnosed with DP at a medical institution. Therefore, future investigations should focus on individuals diagnosed with DP by medical professionals. Second, the test–retest and inter-rater reliability of each testing and scale used were not studied in this study. Future studies will need to confirm the validity and reliability of these tests. Finally, since this study was restricted to Japanese university students, further research should encompass data from various countries to enhance its generalizability. To further validate and explore the relationship between face recognition ability and anxiety, conducting studies with a significantly larger sample that includes diverse ethnicities could offer valuable insights. This approach would facilitate a more comprehensive examination of how cultural backgrounds influence self-perception regarding facial recognition. Subsequent research should explore the connection between face and expression recognition abilities and their implications for psychosocial concerns. Exploring the interaction between facial and expression recognition abilities and anxiety in the future could play a pivotal role in supporting individuals with DP and advancing face perception research.

5. Conclusions

The present study is the first to investigate the relationship between self-reported face recognition abilities and anxiety in young, healthy Japanese individuals using the self-perception face recognition test PI20. The findings indicated that unlike the objective face recognition tests CFMT and VPTA–FFT that showed no association with anxiety, the self-perception test scores may be influenced by state anxiety. Self-reporting, at least in its current form, provides limited insights into predicting face recognition performance in young individuals and diagnosing DP. Therefore, self-reporting is insufficient to evaluate face recognition abilities in young individuals, and DP cannot be diagnosed solely based on self-perception tests. It is necessary to combine self-perceived indicators of face recognition impairment with other perception-based face recognition function tests and consider the presence and extent of anxiety tendencies. Our findings have significant psychological implications for understanding face recognition impairments, DP diagnosis, and clinical practices. In the future, expanding research to investigate the interaction between facial and expression recognition abilities and anxiety is expected to enhance the accurate diagnosis and support for young individuals with facial recognition impairments.

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Ethical approval

This study was conducted according to the Declaration of Helsinki. All procedures were approved by the ethics committees of Niigata University of Health and Welfare (approval number: 17970-180514).

CRediT authorship contribution statement

Yuka Oishi: Writing – original draft, Formal analysis, Data curation, Conceptualization. **Kaede Aruga:** Formal analysis, Conceptualization. **Kohei Kurita:** Formal analysis, Conceptualization.

Declaration of competing interest

None.

Data availability

Data will be made available on request.

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