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Assessment tools for facial recognition: a systematic review

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ABSTRACT – Face recognition is crucial for social interactions. While the criteria for diagnosing prosopagnosia are not yet firmly established, numerous instruments have been developed in recent years to assess face recognition abilities. In this systematic review, we examined assessment tools used for evaluating face recognition and prosopagnosia. We identified 27 studies in which different tests were described, varying in the specific function assessed (e.g., facial memory versus facial perception), format (paper-based or digital), and administration method (self-administered or examiner-guided). Some of the strengths and weaknesses of these tools are discussed in the paper. These findings are valuable for both clinical and research settings, contributing to the identification of prosopagnosia and guiding appropriate interventions.

KEYWORDS: face recognition; neuropsychological tests; test validity; literature review

Ferramentas de avaliação para reconhecimento facial: uma revisão sistemática

RESUMO – O reconhecimento facial é crucial para interações sociais. Embora os critérios para diagnosticar prosopagnosia ainda não estejam bem estabelecidos, vários instrumentos foram desenvolvidos nos últimos anos para avaliar habilidades de reconhecimento facial. Nesta revisão sistemática, examinamos ferramentas de avaliação usadas para avaliar reconhecimento facial e prosopagnosia. Identificamos 27 artigos nos quais foram descritos testes que diferem quanto à função específica avaliada (por exemplo, memória facial versus percepção facial), ao formato (material impresso ou digital) e ao método de administração (autoadministrado ou orientado por avaliador). No artigo, são discutidos alguns dos pontos fortes e fracos dessas ferramentas. Esses resultados são valiosos tanto nos ambientes clínicos quanto na pesquisa, contribuindo para a identificação da prosopagnosia e orientando intervenções apropriadas.

PALAVRAS-CHAVE: reconhecimento da face; testes neuropsicológicos; validade do teste; revisão de literatura

Faces are essential for social interactions, as they allow us to access different information about other individuals, such as emotional state (Torro-Alves et al., 2016), age (Aznar-Casanova et al., 2010), gender (Baudouin & Tiberghien, 2002), attractiveness (Zebrowitz & Montepare, 2008), and identity (Dalrymple et al., 2017). The sudden loss of the ability to recognize individual faces after brain damage was first reported in a scientific journal 150 years ago (Rossion, 2018). In the documented case, the patient identified as LL suffered a stroke that affected the right hemisphere of the brain, resulting in a loss of his ability to recognize familiar people by face. Surprisingly, the patient's reading ability remained intact, with good performance in reading small characters at close range or at a distance (Quaglino et al., 2003).

The term 'prosopagnosia' refers to the inability to recognize faces. It was coined by German neurologist Joachim Bodamer in 1947, deriving from the Greek words "prosopon" (face) and "agnosia" (without knowledge). In his seminal study, Bodamer described three neurological patients who were unable to recognize faces and displayed other forms of visual agnosia (Ellis & Florence, 1990). In general, the inability to recognize faces following brain damage is not associated with low-level sensory impairments or deficits in general intelligence (Barton et al., 2002; Martins & Cunha e Sá, 1999; Rossion, 2022).

In terms of etiology and manifestation, prosopagnosia can be divided into acquired and developmental/congenital types. Acquired prosopagnosia results from brain lesions due to various neurological events, including head trauma, stroke, encephalitis, tumors, degenerative atrophy, or temporal lobe resections (Barton, 2008). In contrast, the origin of congenital or developmental prosopagnosia is not well-established, and it appears to occur without the presence of brain lesions (Albonico & Barton, 2019).

The prevalence of congenital/developmental prosopagnosia is estimated to be about 2% to 3% of the general population (Kennerknecht et al., 2006; Kennerknecht et al., 2008), although some studies suggest higher rates (Bennetts et al., 2017). Adults with prosopagnosia report that difficulty in recognizing other people can lead to traumatic social experiences, resulting in a chronic state of anxiety, feelings of embarrassment, guilt, and a limited social network. In children, prosopagnosia has significant implications for the school environment (Barton & Corrow, 2016; Tsantani et al., 2021).

There is significant variability in the pattern of brain damage associated with prosopagnosia, and it is practically impossible to identify a single damaged cortical region in all or most cases (Barton, 2008; Sergent & Signoret, 1992). Although prosopagnosia is typically associated with bilateral medial occipitotemporal lesions (Damásio et al., 1982; Meadows, 1974), it has also been observed in cases with right occipitotemporal or right/bilateral anterior temporal lesions. These different anatomical manifestations may be related to functional subtypes of prosopagnosia, with occipitotemporal lesions leading to deficits in apperceptive facial processing and anterior temporal lesions in the right hemisphere affecting access to facial memory (Barton, 2008; Damásio et al., 1990; Davies-Thompson et al., 2014). These findings collectively reinforce the concept that facial processing involves the functioning of a broad brain network (Haxby et al., 2000).

Developmental prosopagnosia lacks formal diagnostic criteria and is not officially recognized in the DSM-5 (Burns et al., 2022). In the absence of well-established criteria, some researchers suggest that developmental prosopagnosia could be characterized by performance scores more than two standard deviations below the mean on at least two face recognition tests, compared to neurotypical individuals (Albonico & Barton, 2019; Barton & Corrow, 2016; Dalrymple & Palermo, 2016).

In recent years, there has been an increase in the number of tests available for assessing face recognition (Burns et al., 2022). Generally speaking, tests can be divided into three categories: (a) face perception tests, which involve discriminating simultaneously observed faces; (b) face recognition tests, which assess an individual's face memory capacity; and (c) face identification tests, which involve naming or providing learned information about the person whose face is being analyzed (Albonico & Barton, 2019).

The Benton Facial Recognition Test (BFRT) was one of the first tests to provide a standardized measure of face perception (Murray et al., 2022). In the BFRT, participants must compare the identity of a frontal target face to three of six comparison faces presented simultaneously, but varying according to lighting and viewing angle (Benton & Van Allen, 1968). Despite its popularity, questions have been raised about the reliability of the Benton test (Murray et al., 2022). For example, Duchaine and Nakayama (2004) found that 9 out of 11 patients with developmental prosopagnosia performed normally on the BFRT. Similarly, Albonico et al. (2017) found that 18 out of 23 patients with developmental prosopagnosia obtained scores considered normal on the test.

In recent years, the Cambridge Face Memory Test (CFMT) developed by Duchaine and Nakayama in 2006 has been employed in a range of studies to evaluate face memory in individuals with developmental prosopagnosia (Bowles et al., 2009), autism (O'Hearn et al., 2010; Whyte et al., 2016), and to examine individual variations in face recognition (Elbich & Scherf, 2017; Susilo et al., 2013). While the CFMT is a well-established tool for identifying deficits in facial memory, there remains a lack of a universally accepted test for assessing face perception that involves faces observed simultaneously (Mishra et al., 2021).

In the Cambridge Face Perception Test (CFPT), participants are required to compare a target face to comparison stimuli, which are created by morphing the target face with other faces to varying degrees (Duchaine et al., 2007). However, similar to the BFRT, the CFPT presents certain challenges. It necessitates skillful use of a computer mouse within a limited period, and online administration can be complex, particularly for clinical and older participants (Bate et al., 2008). Additionally, there are questions regarding whether morphologically altered faces are inherently similar (White et al., 2017).

Another form of assessment is the Face Famous Test (FFT). In its standard version, participants view photographs of famous individuals and are asked to name each face (Hodges & Ward, 1989; Sanders & Warrington, 1971). Different versions of the FFT include a variety of photographs, featuring well-known individuals from diverse decades and categories, such as actors, athletes, musicians, media personalities, and/or politicians. Consequently, one of the challenges may pertain to the selection of the stimulus material, given the lack of standardization regarding the target population or even the country of origin (van den Elzen et al., 2023).

Shah et al. (2015) developed the Twenty Item Prosopagnosia Index (PI20), a self-assessment questionnaire designed to quantify traits associated with prosopagnosia. The goal is to assist researchers in diagnosing developmental prosopagnosia by offering a standardized source of self-reported evidence that complements the diagnostic information gathered through objective tasks. A score of 66 or higher on the PI20 may suggest the presence of developmental prosopagnosia.

Given the complexity of the assessment, some researchers have proposed using at least three tests to diagnose prosopagnosia. In such instances, scores falling at least 2 standard deviations below the mean of the reference group would indicate the presence of prosopagnosia (Murray & Bate, 2020). However, this approach does not account for the possibility that the three assessment tasks might measure distinct subcomponents of face processing, which could be selectively impaired (Bate et al., 2019).

In this systematic review, we sought to analyze the assessment tools used for evaluating facial recognition in cases of prosopagnosia. We compiled information regarding the primary characteristics of the instruments employed, the methods of assessment, and the key findings of the studies. Additionally, this paper will discuss some of the advantages and disadvantages of the assessment tools currently available.

This analysis can prove valuable to diverse audiences across various face recognition assessment contexts. For instance, healthcare professionals, such as doctors and psychologists, can benefit from selecting the most suitable tests to identify cases of prosopagnosia, thereby enabling them to customize specific interventions and treatments. It is well known that prosopagnosia can significantly impact professional and personal interactions, and choosing tests is critical for providing the necessary support to those affected. Neuropsychology researchers can assess the characteristics of the tests available for use in clinical or research settings.

METHODS

The systematic review was organized around the following guiding question: What instruments are available in the literature for assessing facial recognition? Searches were conducted in the PubMed, Lilacs, and SciELO databases using the DeCS/MeSH descriptors: (“PROSOPAGNOSIA”) AND (“TEST RELIABILITY” OR “DIAGNOSIS”). Studies were included if they were original articles published in English and provided sufficient detail on the assessment tool. Duplicates, reviews and editorials were excluded. The search was conducted in September 2023.

Selection of studies and data summarization

Initially, two evaluators (GA and MA) independently conducted searches in the databases, completing the first stage of filtering the studies by analyzing their titles and abstracts. Subsequently, a third evaluator (JG) reviewed the selected studies, checking for duplications or inconsistencies in the initial selections, and then applied the eligibility criteria.

Following this, a thematic analysis was conducted on the 27 studies selected by the pair of independent evaluators. To distill the most pertinent information for the review, the following details from the included studies were summarized: 1) author and year of publication, 2) objective of the study, 3) tests used for facial recognition analysis, and 4) main findings.

Quality evaluation

The studies were examined with an emphasis on internal validity, addressing potential issues such as selection, performance, and measurement biases. Throughout the evaluation process, three key aspects of the research evidence were considered: 1) Identification of limitations: This involved identifying potential weaknesses in the research design, for example; 2) Evaluation of consistency: The uniformity and reliability of the results were assessed; and 3) Analysis of precision: this entailed examining the generalizability of the findings and ensuring that sufficient data were available. Studies that did not adequately meet these criteria were excluded from the final selection.

RESULTS

The initial search across the databases yielded 565 studies. Upon screening the titles and abstracts, 27 studies were chosen based on the eligibility criteria (Figure 1). Of these, eleven studies were published in the most recent five years, spanning 2018 to 2023. The remaining papers, constituting 16 studies, were published between the years 2004 and 2017. The CFMT emerged as the most frequently utilized facial recognition test in literature, used in 18 studies. This was followed by the CFPT, which appeared in 11 studies, and the BFRT, employed in 7 studies.

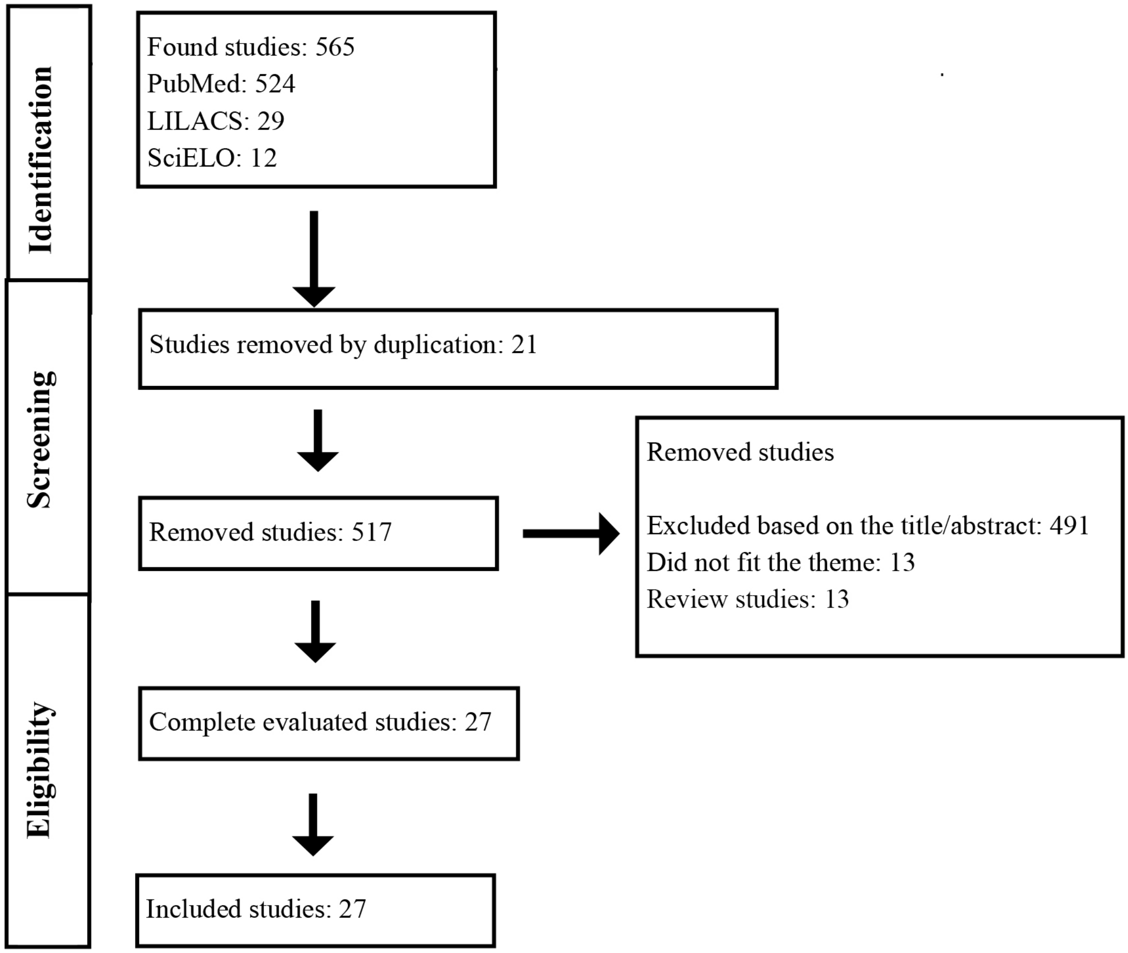

Figure 1
Flow diagram of the systematic review selection process, adapted from the PRISMA diagram (Galvão et al., 2015).

Source: figure prepared by the authors (2023).

A validity study found that the CFMT classified individuals more accurately than the BFRT and the Recognition Memory for Faces (RMF), as reported by Duchaine and Nakayama (2006). Murray and Bate (2020) assessed the test-retest reliability of the CFMT, considering the mode of test administration (online or in the laboratory). The test-retest reliability fell below the level accepted by psychometric standards, yielding a reliability coefficient of 0.68. However, no differences in performance were observed between the tests administered online and in the laboratory.

Bowles et al. (2009), in analyzing the effect of age on the CFMT and CFPT tests, found that older individuals (aged 50 and over) performed less effectively than younger individuals. This difference may be attributed to a reduction in the volume of facial processing areas, particularly in the frontal and temporal regions (Raz et al., 2005). Regardless of the age group, Bowles et al. (2009) observed that women outperformed men, aligning with findings that suggest an advantage for females in face recognition (Biele & Grabowska, 2006; Mancini et al., 2013; McClure, 2000; Montagne et al., 2007). In a study conducted with the CFPT, the results suggested that people with cerebral palsy may have difficulty matching images of the same person that contain natural variations in their appearance (White et al., 2017).

Humphreys et al. (2007) investigated the recognition of facial emotions and facial identity using the BFRT. They found a dissociation between these cognitive abilities, suggesting that the mechanisms involved in facial emotion recognition are distinct from those implicated in facial identity recognition. This observation aligns with the findings from a prior study by Duchaine et al. (2003). In their examination of the patient NM, diagnosed with developmental prosopagnosia, they observed a noticeable deficit in five out of the six facial identity recognition tests. Conversely, NM's ability to discern facial expressions of emotion remained within the normal range in separate evaluations, indicating a dissociation between the processes of recognizing facial identity and emotions.

Rossion and Michel (2018) observed that participants' performance declined in the computerized version of the BFRT (BFRT-c), which includes changes in lighting and rotation of the face. This finding aligns with previous studies that demonstrated significant effects of lighting on recognition (Jenkins et al., 2011; Menon et al., 2015). However, Murray et al. (2022) highlighted that the BFRT-c allows for a reliable measurement of completion times and eases evaluation since it is administered online.

Murray et al. (2022) aimed to improve the assessment of facial processing and introduced a revised version of the test, termed the BFRT-r. They found that the BFRT-r exhibited a pronounced inversion effect and shared a strong correlation with both the BFRT-c and the CFMT, thereby showcasing content validity comparable to other facial processing assessments. Moreover, the BFRT-r demonstrated enhanced sensitivity in detecting impairments in face perception compared to the BFRT-c. In conclusion, the BFRT-r appears to be a promising alternative for evaluating facial processing relative to other versions of the BFRT.

Some tests were used less frequently, including the Face One in Ten Test (Duchaine & Nakayama, 2004; Le Grand et al., 2006), Recognition Memory for Faces - RM (Davies-Thompson et al., 2017; Duchaine & Nakayama, 2006), Face and Name Learning Test I, Emotion Expression Judgment, Face and Name Learning Test II, Delayed Matching to Sample of Faces and Eyeglasses (Dobel et al., 2007), and the Cambridge Face Memory Questionnaire - CFMQ (Arizpe et al., 2019).

Table 1 presents the principal characteristics of the studies analyzed. This analysis includes studies that employed tests to assess facial recognition in samples of both healthy individuals and those diagnosed with prosopagnosia. Notably, only one study compared individuals with developmental prosopagnosia and acquired prosopagnosia.

Most of the studies utilized tests to evaluate facial recognition in individuals with developmental (congenital) prosopagnosia, to discern differences in comparison to healthy individuals. Overall, the results suggested that patients with developmental prosopagnosia exhibited deficits in perception and memory, and experienced greater difficulty in classifying facial expressions, recognizing facial identity, and identifying famous faces.

Table 1
Selected studies using tests for facial recognition analysis in individuals with prosopagnosia.

Authors/year	Objective	Tests used for face recognition	Main results
Duchaine & Nakayama (2004)	Testing individuals with developmental prosopagnosia using the BFRT to systematically assess whether patients with developmental prosopagnosia can pass it.	Face One in Ten Test; Faces Old/New 1 Test; Faces Old/New 2 Test; Benton Facial Recognition Test (BFRT).	Patients with DP are generally able to complete the BFRT, but they often require more time to do so compared to healthy patients, although some individuals with DP respond more quickly.
Duchaine, & Nakayama (2006)	Evaluating the validity of the CFMT.	Cambridge Face Memory Test (CFMT); BFRT; Recognition Memory for Faces (RMF).	The comparison of CFMT, BFRT, and RMF revealed that CFMT accurately classified 75% of prosopagnosic individuals, whereas BFRT and RMF correctly classified only 25% and 38%, respectively.
Le Grand et al. (2006)	Investigating what aspects of face processing are impaired/spared in developmental prosopagnosia.	The Famous Face Recognition Tests; "One in Ten" test.	Four participants with DP exhibited a normal pattern of face classification. At least half of the sample displayed impairments in facial identity processing, as evidenced by issues related to the external contour, spacing of internal features, or judgments of attractiveness.
Dobel et al. (2007)	Comparing six cases of congenital prosopagnosia to unimpaired participants using standardized test batteries, tailor-made experimental paradigms, and clinical questionnaires.	Bielefelder Famous Faces Test; Face and Name Learning Test I; Emotion Expression Judgment; Face and Name Learning Test II; BFRT; Delayed Matching to Sample of Faces and Eyeglasses.	Prosopagnosic individuals displayed deficits in recognizing famous faces and had a limited ability to retain new faces for short periods. Their judgment of emotional expression, speech reading, and memory for faces and names was only mildly impaired. No evidence was found for general visual deficits or social dysfunction.

Table 1
Cont.

Authors/year	Objective	Tests used for face recognition	Main results
Duchaine et al. (2007)	Investigating whether individuals with Developmental Prosopagnosia (DP) exhibit a specific pattern of deficits concerning global vs. local processing, as previously reported in studies.	Famous faces Test; Cambridge Face Perception Test (CFPT); CFMT; Eyes Test; Global-local Tasks;	Deficits in memory and perception were observed in individuals with DP. In the task that assessed global-local processing performance, individuals with DP displayed average performance similar to that of the control group. They exhibited a typical global advantage and typical global-to-local consistency effects, similar to the individuals in the control group.
Humphreys et al. (2007)	Investigating whether the ability to recognize facial expressions can be preserved in the absence of recognizing facial identity remains controversial.	Famous Face Recognition; Unfamiliar Face Discrimination; BFRT.	Facial expression processing in the group of three individuals with DP indicated that facial expression processing was at normal levels in all three of them. However, it was severely compromised in two individuals when compared individually with the participants with acquired Prosopagnosia (PAd). On the other hand, the two individuals with PAd showed marked difficulties with most expressions.
Bowles et al. (2009)	Assessing the extent to which norms for CFMT and CFPT must consider ageing, sex, and the testing country.	CFMT; CFPT.	The finding that the diagnostic threshold for prosopagnosia was influenced by age, participant ethnicity (within Caucasians), and sex for middle-aged and older adults in the CFPT.
McKone et al. (2011)	Developing the "CFMT-Australian" (CFMT-Aus), which complements the CFMT-original by using ethnicity better matched to a different European subpopulation.	CFMT – Aus; CFMT.	The reliability (0.88) and validity (convergent, divergent using trolleys, inversion effects) of the CFMT-Aus were confirmed. The ethnicity depicted by the face has subtle effects on facial processing, even in normal participants. The CFMT-Aus clarifies the diagnosis of prosopagnosia, and the study revealed that face memory at short intervals (3 minutes, 20 minutes, and 24 hours) leads to overlapping processes in normal participants.
Palermo et al. (2011)	Assessing the extent of holistic processing of facial expressions and facial identity in individuals with DP in comparison to healthy individuals.	Maccs Famous Face Test 2008 (MFFT-08); CFMT; CFPT; Ekman 60 Faces Test.	The clinical group exhibited weaker holistic processing for both facial expression and facial identity information. Therefore, normal facial expression recognition in individuals with DP may be a result of compensatory strategies.
Biotti & Cook (2016)	Describing three complementary experiments that examine emotion recognition in a sample of 17 developmental prosopagnosic individuals.	Twenty-Item Prosopagnosia Index questionnaire (PI20); CFPT; CFMT.	The first two experiments revealed a reduced ability in individuals with DP to classify facial expressions. After dividing the clinical sample into two subgroups, apperceptive and non-apperceptive, it was particularly evident that inaccurate expression categorization was more pronounced in those individuals exhibiting apperceptive profiles.

Table 1
Cont.

Authors/year	Objective	Tests used for face recognition	Main results
Esins et al. (2016)	Assessing various aspects of facial recognition as well as other aspects of object recognition.	CFMT; Surprise recognition test; Composite Face Test; Facial Motion Advantage Test.	Significant differences in performance were observed between individuals with prosopagnosia and those in the control group in all face tests, while both groups did not differ in object recognition tests. Prosopagnosic individuals exhibited significant deficits in face recognition tasks, including holistic processing and reduced processing of face configuration information. While the control group recognized dynamic faces better than static faces, this effect was not observed in the clinical group. The clinical group also showed a significantly reduced reliability coefficient in the CFMT.
Ulrich et al. (2016)	Investigating the possibility that some cases of DP are caused by memory impairment, with any perceptual complaints merely allied rather than causal.	CFMT; CFPT; The Mooney Face Task.	Six of the 11 individuals did not show evidence of perceptual impairment. In the remaining five individuals, no single perceptual deficit, or combination of deficits, was necessary or sufficient for poor recognition performance. These data suggest that some cases of DP are better explained by a memorial rather than a perceptual deficit and highlight the relevance of the apperceptive/associative distinction more commonly applied to the allied syndrome of acquired prosopagnosia.
Davies-Thompson et al. (2017)	Evaluating a perceptual learning program that incorporated variations in view and expression, which was aimed at training perceptual stages of face processing with an emphasis on ecological validity.	CFMT; CFPT; RMF; BFRT; Familiarity: Famous faces.	The control task did not affect perception, and training enhanced perceptual sensitivity for the trained faces, which generalized to new, untrained expressions of these faces. The improvement extended to new faces, and the benefits were sustained for three months. The training was more effective for individuals with more pronounced initial perceptual deficits.
Fisher et al. (2017)	Assessing whether the activation of visual working memory for individual faces is selectively impaired in DP.	Famous Faces Test; CFMT; CFPT.	Participants with DP exhibited impaired performance in the identity task but performed at the same level as controls in the expression task. The results indicate a specific deficit in facial visual memory related to identity in individuals with DP.
McKone et al. (2017)	Demonstrating the methodological suitability of CFMT - Chinese.	CFMT - Chinese.	The CFMT: Chinese is methodologically suitable for diagnosing prosopagnosia in Chinese participants, with high internal reliability ($\alpha = 0.86$), an approximately normal distribution, and sample-standard scores well above chance.

Table 1
Cont.

Authors/year	Objective	Tests used for face recognition	Main results
White et al. (2017)	Testing face identification ability in six people with DP, who are severely impaired on face memory tasks, using tasks that do not rely on memory.	CFPT; GFMT.	Participants with DP showed a relatively unimpaired performance on a standard test of face matching ability, indicating that they can achieve normal levels of accuracy on the GFMT despite deficits in central face recognition ability. However, a pronounced deficit in face matching was observed, suggesting that individuals with DP have difficulty recognizing individuals when faced with natural everyday variations in a person's appearance.
Rossion & Michel (2018)	Providing up-to-date performance standards for the BFRT, including the time taken to complete the test, as assessed in an electronic version of this (BFRT-c).	Computerized Benton Facial Recognition Test (BFRT-c)	Although response reliability and accuracy were relatively low, this was primarily due to the significant variability in item difficulty. The response time measured in this version (with an average of 3 minutes) offers a reliable complementary measure.
Arizpe et al. (2019)	Evaluating the utility of the CFMQ in the identification of individuals with prosopagnosia.	Cambridge Face Memory Questionnaire (CFMQ); CFMT; Famous Faces Memory Test (FFMT); PI20.	The CFMQ demonstrated strong validity, with high correlations of 0.44 with CFMT and 0.52 with FFMT. However, cut-off analyses revealed that no CFMQ score produced a combination of clinical-grade sensitivity and positive predictive value in individuals sufficient to support its use as a standalone screening or diagnostic test.
Murray & Bate (2020)	Assessing the test–retest reliability of the Cambridge Face Memory Test (CFMT).	CFMT; CFMT-Aus; CFPT; Famous Face Test.	It was found that there were no significant differences in test-retest effects between participants who completed the tasks online and those who did so in the laboratory. Additionally, performance of the first 48 items of the CFMT was equally sensitive to the total score of all 72 items, suggesting that the test can be shortened for efficiency.
Matsuyoshi & Watanabe (2021)	Examining the relationship between the two representative self-report face recognition questionnaires (PI20 and HK questionnaire) and assessing the extent to which these questionnaires differ in their relationship with face recognition performance in normal populations, excluding predetermined extreme groups.	PI20; 15-item questionnaire in a Hong Kong population (HK questionnaire); Taiwanese Face Memory Test (TFMT).	The results indicated that both questionnaire scores had moderate correlations with face recognition performance (approximately $r = 0.3$), with the strongest correlation observed for HK11 as compared to PI2.
Stantic et al. (2022)	Developing the OFMT, establishing the range of performance on the measure to assess its utility in measuring individual differences, and comparing the OFMT scores with those of the CFMT and PI-20.	PI20; CFMT; Glasgow Face Matching Test (GFMT); Oxford Face Matching Test (OFMT).	The OFMT was found to be sensitive to individual differences in the typical population as well as in groups of prosopagnosic and over-recognizing individuals. The test-retest reliability of the task was on par with that of the CFMT and the GFMT.

Table 1
Cont.

Authors/year	Objective	Tests used for face recognition	Main results
Svart et al. (2022)	Exploring whether individuals with self-reported DP also report signs of other neurodevelopmental disorders, deficits, or conditions (developmental comorbidity).	PI20	Overall, 54% reported a developmental comorbidity, with the majority indicating specific cognitive impairments (e.g., memory) rather than diagnostic categories (e.g., attention deficit hyperactivity disorder).
Burns et al. (2022).	Enhancing the understanding of DP cases that are excluded by more traditionally employed tests, highlighting their limitations, and proposing a novel approach to PD diagnosis.	CFMT; Famous Faces Test; Cambridge Face Perception Test inverted scores (CFPTinv); Cambridge Face Perception Test upright scores (CFPTup); Cambridge Face Perception Test Holistic Perception measure; PI20.	The excluded PD cases were found to exhibit impairments in practically all aspects of facial processing. Furthermore, in some instances, they encountered difficulties comparable to those in classic cases, suggesting key shared characteristics across both subgroups of this condition. Additionally, a new approach was proposed for researchers to comprehensively diagnose and study prosopagnosia.
Bate et al. (2022).	Examining the effectiveness of a facial training program in adults and children with facial recognition difficulties.	CFMT; CFPT; Cambridge Car Memory Test; Cambridge Car Perception Test.	Improvements in facial memory were observed in three of the participants. While there was also improvement in facial perception, there was mixed evidence regarding the facial specificity of these gains. Collectively, these findings suggest plasticity in the human facial recognition system extending at least until mid-adulthood, and they also open the door for longer-term implementations of the face training program, likely to result in greater improvements for both adults and children.
Murray et al. (2022).	Assessing the validity of the BFRT-r in typical participants, providing normalization data for comparison in clinical cases, and evaluating the diagnostic utility of the test along with the BFRT-c in DP.	BFRT-c; Benton Facial Recognition Test- Revised (BFRT-r); CFMT;	The BFRT-r showed good internal reliability and content validity in a sample of typical participants. However, a subsequent assessment revealed that older participants took longer to complete it, underscoring the need for age-appropriate norms. Additionally, when administered to 32 individuals with developmental prosopagnosia, the BFRT-r exhibited greater sensitivity in diagnostic screening compared to the BFRT-c.
Little et al. (2023).	Investigating whether preferences for horizontal information in faces are associated with face recognition abilities in a typical sample and whether such preferences are absent in individuals with developmental prosopagnosia.	CFMT.	Overall, the study demonstrated that the preference for horizontal information in faces is associated with typical variations in facial recognition skills but is not impaired in individuals with DP.
Portch et al. (2023).	Developing an understanding of familiar face recognition in individuals with DP, including the reasons for both successful and unsuccessful performance.	FFMT.	The results suggest that individuals with DP can successfully and frequently employ compensatory strategies to recognize faces, and these strategies support most cases of preserved familial face recognition.

Source: figure prepared by the authors (2023).

DISCUSSION

In this systematic review, we identified 27 studies in which tests were used to assess facial recognition skills. These tests vary in several aspects, including the type of facial ability analyzed (e.g., face memory or face perception), the format of the materials used (printed or digital), and the method of administration (self-administered or conducted by an evaluator). Our review revealed that the CFMT, the CFPT, and the BFFT were the tests most frequently used across studies.

The CFMT assesses facial memory using unfamiliar faces. In the CFPT, participants are presented with a profile view of a target face alongside several frontal-view faces. These frontal-view faces exhibit varying degrees of similarity to the target face, and participants must identify the face that most closely resembles the target face (Duchaine et al., 2007). Regarding the BFRT, participants are shown a target face along with six comparison faces simultaneously, and they must select the three faces that best match the target (Benton, 1983).

Dahl et al. (2014) contend that it is important to adapt tests to the ethnicity of the individuals being assessed, given the phenomenon known as the own-race advantage. Accordingly, some studies have sought to adapt the CFMT to various ethnocultural contexts. The CFMT-Aus was tailored for an Australian context, while the CFMT-Chinese was adjusted for a Chinese context. The CFMT-Aus demonstrated effectiveness in terms of reliability and validity, and the CFMT-Chinese was suitable for diagnosing prosopagnosia among East Asian participants (McKone et al., 2011; McKone et al., 2017).

The advantage of utilizing tests such as the CFPT and BFRT is that they assess an individual's ability to recognize faces through face matching, thereby evaluating the perceptual aspect of face recognition. However, the online administration of the CFPT seems to present challenges, especially for clinical participants and older individuals (Bate et al., 2008). One benefit of using the BFRT for facial recognition assessment is its straightforward procedure and quick administration (Murray et al., 2022). The lack of a maximum response time allows individuals to employ strategies that facilitate their responses. Duchaine and Nakayama (2006) found that six out of eight participants with prosopagnosia achieved scores classified as normal on the BFRT, even though they scored poorly on the CFMT. This highlights the importance of using the BFRT in conjunction with other facial recognition tests (Davies-Thompson et al., 2017; Dobel et al., 2007; Duchaine & Nakayama, 2004).

Other tests have been developed to assess the recognition of famous faces, including: Familiarity: Famous faces (Davies-Thompson et al., 2017), Famous faces: a version for US and Canadian participants and a version for UK participants (Duchaine et al., 2007), Famous Faces Test - FFT (Fisher et al., 2017; Murray & Bate, 2020), MACCS Famous Face Test-08 (Palermo et al., 2011), the Bielefelder Famous Faces Test (Dobel et al., 2007), and Famous Faces Memory Test - FFMT (Arizpe et al., 2019). However, these recognition tests have limitations, such as the use of non-standardized stimuli. Additionally, certain non-facial information could also bias responses, such as a US flag in the background of a photograph of a US president (van den Elzen et al., 2023). The Twenty Item Prosopagnosia Index (PI20), a self-report measure, was used in six studies (Arizpe et al., 2019; Biotti & Cook, 2016; Burns et al., 2022; Matsuyoshi & Watanabe, 2021; Stantic et al., 2022; Svart & Starrfelt, 2022). Shah et al. (2015) found that the PI20 was the strongest predictor of performance in face identification and exhibited a strong correlation with the Glasgow Face Matching Test (GFMT). This provides additional evidence of construct validity for the PI20 and highlights its potential for use.

CONCLUSION

In this systematic review, we noted that studies on facial recognition spanned a broad spectrum of objectives, encompassing the exploration of facial identification skills in individuals with prosopagnosia, healthy participants, and the evaluation of psychometric parameters associated with these tests. This review underscores the challenges in selecting the most appropriate instruments due to their cultural adaptation and inherent limitations. Given the complexity involved in evaluating prosopagnosia, there is a pressing need for additional research to enhance the sensitivity and accuracy of face recognition tests.

Furthermore, the study emphasizes the significance of validating and culturally adapting facial recognition tests, particularly regarding ethnic and cultural variations. Accounting for these cultural differences is crucial, as it not only enhances the precision of the assessments but also mitigates bias in the outcomes, ensuring the applicability of the tests across diverse settings. Consequently, these findings have practical implications for researchers and healthcare professionals dedicated to assessing facial recognition abilities in different populations and cultural contexts.

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Conflict of interest

The authors have no conflicts of interest to declare.

Data availability statement

The data supporting the findings of this study can be requested from the corresponding author upon reasonable request.

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