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A correlational study investigating whether semantic knowledge facilitates face identity processing

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ABSTRACT
The ability to recognize faces is a fundamental skill in human social interaction. While much research has focused on the recognition of familiar faces, there is growing interest in understanding the cognitive processes underlying the recognition of unfamiliar faces. Previous studies have suggested that both semantic knowledge and physical features play a role in unfamiliar face recognition, but the nature of their relationship is not well understood. This study examines the relationship between unfamiliar face recognition ability and the encoding abilities of semantic knowledge and physical features for famous faces. Using the Gorilla platform, a large group of participants ($N = 66$) with a broad age range completed three tasks: a challenging unfamiliar face matching task and Famous People Recognition Tests 1 and 2 to evaluate semantic and physical feature encoding abilities, respectively. Results indicate positive correlations between encoding abilities for both semantic knowledge and physical features of familiar faces with Model Face Matching Task scores. Additionally, the encoding ability for semantic knowledge was found to be positively associated with that of physical features.

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1. Introduction

Faces reveal a vast amount of information to a perceiver, such as age, sex, mood, attractiveness, intention, and eye gaze. As a primary component presented during social interactions, faces are often used for individual identification and recognition. Despite the presence of other cues, such as voice, body shape, gait, or sometimes clothing, which might help identification, faces are the key indicator of one's identity because of their uniqueness. Faces are also used for recognition and identification, similar to fingerprints and DNA. For instance, individual faces are recorded as biometric photos used in real-life contexts, such as law enforcement and security systems, eyewitnesses, and inspection of passports or identity cards [1]. Although the general accuracy in eye-witnesses for crimes is relatively low, some people are better at recognizing unfamiliar faces, and the factors that might contribute to this difference remain unclear.

In the domain of face recognition studies, the ability of face processing consists of three main parts: unfamiliar face recognition, familiar face recognition, and novel face learning. Unfamiliar face recognition is defined as the act of deciding whether two simultaneously presented faces, neither of which had been perceived by the participants before, were different views of the same individual. It also refers to the process for a participant to decide that a displayed face, unknown to them before the beginning of the experiment, is being presented again. In contrast, recognition of famous or personally known faces and previously unknown faces after experiencing an extensive learning phase is defined as familiar face recognition [2].

In both lab research and everyday life, face recognition is usually accompanied by retrieving semantic information about the individual being recognized, such as their occupation or where they are typically encountered. Making a judgment of personality traits and semantic information about a face results in better subsequent recognition, according to the Levels of Processing framework. This framework suggests that the more deeply an item is processed by the cognitive system, the better it is recalled [3]. Therefore, the ability to encode semantic information for faces may contribute to better recognition ability for unfamiliar faces.

2. Preliminary study of face encoding and recognition

2.1 Impact of semantic information on novel face encoding and recognition accuracy

Previous studies have shown evidence that encoding abstract traits of novel faces leads to better recognition performance than those of physical traits. The study

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investigating the semantic information of novel face encoding showed that a judgment about the honesty or likableness of the person represented in a picture leads to better recognition of that photo than a judgment about the person's gender [4]. Similar results were found by Winograd [5], who investigated face recognition after one of nine judgments was made during the initial encoding of novel faces. During the encoding phase, subjects were instructed to rate faces on one aspect that either refers to their physical characteristics (e.g., big nose and straight hair) or abstract traits (intelligent, anxious, or friendly) and occupations. They found recognition accuracy was lower when physical judgments were made about the faces than when abstract judgments were made [6]. This is consistent with the findings of which subject encoding faces in terms of personality characteristics resulted in better recognition than subjects whose processing was based on physical facial features [7]. Similar patterns of results have been replicated with different age groups including children and elder people [8]. Thus, it is possible that the encoding of personal semantic information requires a deeper encoding of faces than observable facial features.

This kind of influence has also been demonstrated by applying a different assessment method to determine whether semantic information influences the encoding of preciously unfamiliar faces. Subjects were presented with faces that were either accompanied during encoding with an occupational label that was stereotypically congruent or incongruent with that face. They found a selective stereotype priming effect, in which faces that are presented with a congruent stereotype label (i.e., occupation label) are better recognized subsequently [9]. This shows that stereotype-congruent novel face encoding is benefitted from the presentation of semantic information. The finding successfully replicates the effect found by Klatzky et al. [10], which suggests that semantic interpretations affect subsequent recognition and that there is higher sensitivity for faces with congruent occupation labels [10]. Thus, there might be deeper processing for personality information that underlie the better performance on face memory and there might be certain beneficial effects for face encoding with semantic information, but the effect may be selective and dependent on congruency.

Although it was found that semantic encoding of a face may facilitate face recognition accuracy, previous models of face processing do not explicitly provide explanations for this effect. The functional. The model proposed by Bruce and Young [10] suggests that structural encoding processes are responsible for producing descriptions that can be used to analyze facial expressions and speech [11]. Familiar face recognition involves a match between the products of structural encoding and previously stored structural codes, describing the appearance of familiar faces, stored in Face Recognition Units (FRUs). Identity-specific semantic codes are then accessed from Person Identity Nodes (PINs), and subsequent name codes are retrieved. Based on Bruce and Young's [11], functional model, the IAC-L model was proposed as a neural network system for face recognition [12]. It is suggested that perception of a specific face leads to activation of corresponding FRUs specialized for every familiar face. Individual FRU is connected to Voice Recognition Units (VRUs), Semantic Information Units (SIUs), and Name Recognition Units (NRUs) respectively, via Personal Identity Nodes (PINs). This structure allows the propagation of activation from semantic nodes to the FRUs through reciprocal excitatory links between the SIU, PIN, and FRU. Therefore, the presentation of pieces of personal information of celebrity will activate semantic nodes, PINs of which linked, and to existing FRUs which correspond to the faces. Although the IAC-L model assumes that FRUs can be linked to SIUs and semantic information is activated by previously known faces, it does not provide plausible explanations for predicting any facilitation of encoding semantic information in novel face encoding.

Despite evidence was found supporting that semantic encoding could benefit novel face recognition, other studies have found a selection of the most distinctive features in a face during encoding (a surface judgment) results in similar recognition accuracy when making an abstract judgment during encoding [13]. This suggests that apart from the encoding of semantic memory, physical facial traits may also contribute to the difference in novel face recognition abilities.

Courtois and Mueller [14] argued that the critical factor determining face recognition accuracy was the number of facial features assessed during encoding. According to the Holistic processing theory, one of the perceptual integrations of face information is processing of the "second-order" ways in which a face deviates from the basic shared first-order configuration found in all faces (i.e., two eyes, above the nose, above the mouth). Based on this, another theory proposed a single holistic representation of all facial information including both spacing information and second-order information about the exact shape of local features (e.g., eye shape and nose size) [15].

A study using changed faces and unchanged faces from presentation (i.e., facial cues, such as angle and expressions) to test found that both accuracy and efficiency of unfamiliar face recognition were worsened by changes in facial features, while for unfamiliar faces there was a reduction in efficiency [16]. This suggested encoding for physical facial features contributes significantly to novel face recognition. However, studies also found that major changes in facial features fail to reduce recognition ability significantly [7]. Plus, the part-whole effect shows poorer memory for isolated face parts than the memory in the context of the original whole face [17], suggesting the processing of whole faces may use a different cognitive mechanism as the processing of separate facial features.

2.2 Preliminary investigation of semantic memory and physical facial features using MFMT, FPFR1, and FPFR2

Previous studies provided evidence supporting the influence of semantic information for benefiting from novel face recognition, but without developing quantitative measurements for the amount of semantic memory and physical facial features encoded, and investigating the potential correlations between semantic memories stored for familiar faces and unfamiliar faces recognizing ability. We, therefore, investigated the associations between performance in unfamiliar face matching and famous people face recognition tasks, using the short version of Model Face Matching Task (MFMT) as an objective assessment of unfamiliar face matching ability; the Famous People Face Recognition test1 (FPFR1) as a measurement of semantic memory; and Famous People Face Recognition test2 (FPFR2) for measuring physical features encoding ability for famous faces. These measures were integrated into three tasks that employed a within-subject, correlational design, investigating how they were related to one another.

In Task 1, MFMT was applied to assess novel face recognition. MFMT and tests resembled are often used in criminal justice systems, such as national security officials, for examining the authenticity of individual passport identity and identification of the potential crime perpetrators. Besides, it is used in daily security settings, such as retail stores to prevent illegal sale of age-restricted items [1]. The original MFMT is comprised of 120 male Caucasian faces. For this study, MFMT (short version) was used and consists of 90 pairs of simultaneously presented unfamiliar faces, 45 of which are the same identity face pairs and 45 of which are different. During the test, subjects were asked to indicate whether the two faces of each trial represent the same person by clicking on one of the two choices given on the screen ("same" or "different") under no time constraints. Test performance was determined using the percentage of correct responses for each participant.

In Task 2, FPFR1 aimed to determine the cognitive abilities for encoding semantic knowledge for familiar faces. In humans, the conscious recollection of facts and events is formed relying upon the capacity of long-term memory, which comprises episodic memory and semantic memory. Semantic memory involves general knowledge such as concepts and facts, while episodic memory is the recollection of events and experiences [18]. In the present study, semantic knowledge is defined as nonvisual abstract information used for encoding previously known faces, including biographical facts, history, status, and initials. Participants were given a recognition test and asked to come up with facts relating to the presented famous face, such as surname, occupation, age, and famous pieces of work. Responses include both semantic and episodic memories for the face presented were accepted and recorded as FPFR1 Score.

Besides, a procedure of which a simpler version of the remember/know (R/K) paradigm, first introduced by Tulving [19], also used by Westmacott and Moscovitch [20], was adapted and applied for FPFR 1 to assess semantic memories previously acquired for the presented celebrities before the experiment. In the previous study, participants were given a recognition test and asked to classify each item they recognize into one of two categories, remember (R) or know (K) [20]. In contrast, in the current study, only remember (R) responses were recorded. As previously proposed, knowing was defined as recognizing someone during an encounter but being unable to remember anything about them other than that they are familiar [21]. Therefore, know (K) responses are removed since knowing or recognizing the celebrity does not indicate sufficient previously stored semantic information about the recognized face. Plus, all responses provided during FPFR 1 were included regardless of true or false information because this task aims to determine semantic retrieval capacity during recognition, and both correct and incorrect information previously learned were encoded for memory consolidation and contribute to recognition. The analytic techniques we used to make judgments for the number of facts focus on the quantity of semantic information rather than accuracy. Thus, all facts provided by subjects were included regardless of accuracy.

For Task 3, FPFR 2 was used to assess the cognitive abilities for encoding physical features for famous faces, and FPFR2 Scores were obtained. Participants were presented with the same eight famous faces in FPFR1 and asked to provide physical facial features relating to the presented faces, such as eye color, nose, and lip shape. In this study, physical facial features are defined as visual information used for encoding previously known faces. Single whole-face processing involves encoding based on both representations of all facial information, including both inner, expressive features (i.e., eyes, nose, and mouth) and outer contours (i.e. second-order information such as hair, ear, and neck) of a face [22]. Thus, all responses including both inner and outer facial features for faces were accepted and recorded as FPFR2 Score.

In summary, this study aims to examine whether semantic and facial features encoding abilities might account for individual differences in unfamiliar face recognition. Hypotheses were as follows: 1) people who have more semantic memory for familiar faces would be better at unfamiliar face recognition; 2) people who could more actively encode facial differences benefit themselves from having a better unfamiliar face recognition ability; 3) The ability to encode semantic information and facial features are not correlated.

3. Methodology

3.1 Participants

Participants were recruited through opportunity sampling from online platforms, including Facebook, Instagram, and WeChat, resulting in a diverse sample. A total of 74 subjects were invited to participate in the experiment, but incomplete responses were excluded from the analysis, resulting in a final sample of 66 subjects (21 males, 44 females, and 1 who did not declare their gender), yielding a completion rate of 89.19%. The mean age of the participants was 22.23 years (SD = 2.85, range 20–33), and all had normal or corrected-to-normal vision. The study was approved by the ethical review board of the Psychology department at the University of York, and all participants provided informed consent before taking part in the experiment.

3.2 Experiment design

A within-subject, correlational design was implemented. The correlations assessed whether there are any relationships among the three factors investigated: the amount of semantic knowledge (FPFR1), physical facial features (FPFR2) encoded for celebrities' faces, and unfamiliar face matching ability (MFMT).

3.3 Materials and procedure

The study involved two web-based tasks designed and administered via Gorilla. Both tasks required internet access but could be completed from any location and at any time during the data collection period. The study comprised three separate tasks: the Model Face Matching Task (MFMT), Famous People Face Recognition Test 1 (FPFR1), and Famous People Face Recognition Test 2 (FPFR2). Participants were divided into two groups ($N = 33$) and randomly assigned to one task first, then completed the others, thereby counterbalancing the tasks. A pilot study was conducted before the experiment to ensure that the famous people included in the tests were well-known to the sample group and to determine appropriate time limits for task completion.

3.3.1 Models Face Matching Task (MFMT)

The MFMT [1] is a perceptually difficult unfamiliar face-matching task that measures participants' facial matching ability. MFMT (short version) was used for the current study of which consists of 90 pairs of simultaneously presented unfamiliar faces, 45 of which are the same identity face pairs and 45 of which are different identity face pairs. All images measured 300(W) × 420 (H) pixels and were shown in color to mimic natural settings when face matching would occur. Each face image is front-facing in pose, neutral in expression. The images exclude the presence of any observable jewelry, but clothing and hairstyles were visible. Ratings for mismatched trails were collected adopting a method devised from the previous study [23]. All participants were tested individually using the Gorilla Experiment Builder [24]. A laptop screen or computer monitor was used for displaying the stimuli. Participants are required to decide whether the two faces of each trial represent the same person and made their responses using a single mouse click to choose one of the two choices given on the screen ("same" or "different") under no time constraints. Each subject saw all 90 pairs of faces, with the two images matching on half of the trials. The trials were presented in a randomized order.

3.3.2 Famous People Face Recognition test1 (FPFR1) (Semantic Knowledge)

An effort was made to select faces of people who had remained famous. It is difficult to find personalities who have been famous across all age groups. The pictures included politicians, singers, film, and TV celebrities. Eight celebrities' faces (four males and four females) were obtained from the Internet and used as experimental materials. The full list of famous people used in the test includes Donald Trump, Daniel Radcliffe, Emma Watson, Michael Jackson, Angelina Jolie, Beyoncé Giselle Knowles, Justin Bieber, and Taylor Swift. Colored portrait photographs were used. Participants sit in front of a laptop screen or computer monitor and receive instructions for Task 2 from the shown slides. There were 8 trials in Subtask 1. In each trial, one celebrity's face was presented for 2 min. During the presentation of each face, participants were encouraged to provide as many detailed descriptions of knowledge ("facts," e.g., occupation, nationality, family member name, favorite food, favorite country, movies they acted in, songs they produced) related to the famous face represented as possible. Subjects made their responses by typing the answers in a textbox provided under the represented face. Scores were thereby obtained for the average number of facts of eight represented faces.

3.3.3 Famous People Face Recognition Test2 (FPFR2) (physical feature encoding)

The same FPFR1 design was used for FPFR2. During the presentation of the face item, participants were asked to remember as many "physical features" (e.g., eye color, lip color, and nose shape) of each celebrity's face as possible and give their responses by typing the answers in a textbox provided under the celebrity's face. Scores were thereby obtained for the average number of physical features of eight represented faces.

4. MFMT results analysis

The MFMT score was calculated by taking the mean score across 90 trials of the MFMT for each subject. Participants who did not respond in FPFR1 (i.e., no recognition for any celebrities) were excluded from the analysis. For FPFR1 and FPFR2 results, the number of unique facts and physical features for each celebrity were counted. The mean number of facts and physical features were calculated and recorded for each participant. Both were then correlated with MFMT results. Sample sizes, means, and standard deviations of the three variables of interest are presented in Table 1.

The normality of MFMT, FPFR1, and FPFR2 was assessed using the Shapiro–Wilk test. The results showed that MFMT scores were normally distributed ($W[66] = 0.98$, $p = .332$), but FPFR1 ($W[66] = 0.93$, $p = .001$) and FPFR2 ($W[66] = 0.96$, $p = .036$) were not. Therefore, a nonparametric procedure, Spearman's rank-order correlation coefficient, was used to analyze the data.

Table 1. Descriptive statistics.

	Mean	Std. Deviation	N
MFMT	0.66	0.09	66
FPFR1 (Fact)	4.02	2.69	66
FPFR2 (Feature)	5.16	2.60	66

The results of the Spearman's rho indicated a statistically significant moderate association between FPFR1 and MFMT scores ($rs[66] = .413$, $p = .001$). A scatterplot depicting this relationship is shown in Figure 1. The results also show a statistically significant weak association between FPFR2 and MFMT scores ($rs[66] = .361$, $p = .003$), as shown in Figure 2. Finally, the results reveal a statistically significant strong association between FPFR1 and FPFR2 ($rs[66] = .751$, $p < .001$), as shown in Figure 3.

These findings suggest that an increase in the number of fact responses was associated with increases in MFMT scores, and an increase in the number of physical feature responses was also associated with increases in MFMT scores. Furthermore, there was a strong positive relationship between the number of facts and physical features provided.

5. Discussion

5.1 Correlating semantic and physical encoding in novel face recognition

This study aims to investigate the correlations between semantic information and physical facial feature encoding for famous faces with novel face recognition ability. The study tested three hypotheses: 1) people who have more semantic memory for familiar faces would be better at unfamiliar face recognition; 2) people with better facial

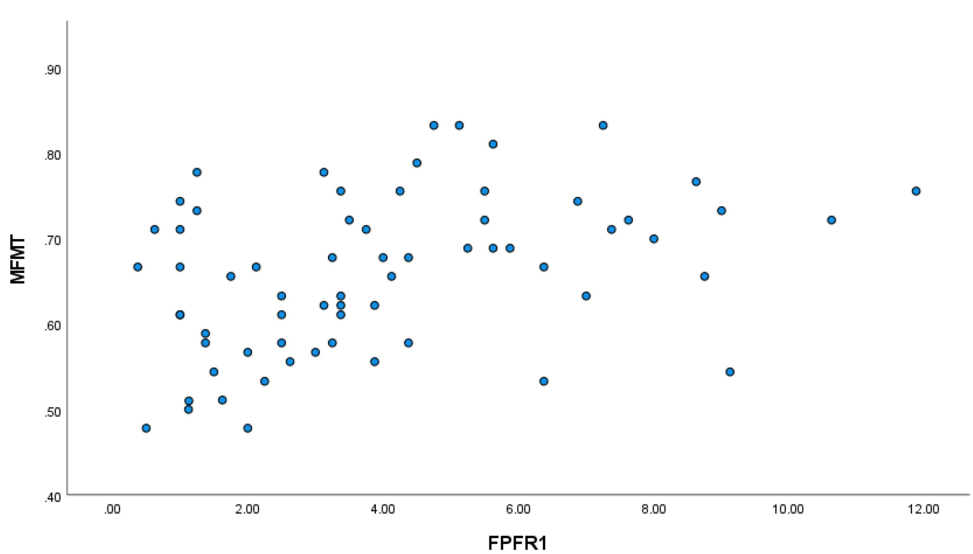

Figure 1. Scatterplot illustrating the positive relationship between FPFR1 (Fact Scores) and MFMT Scores.

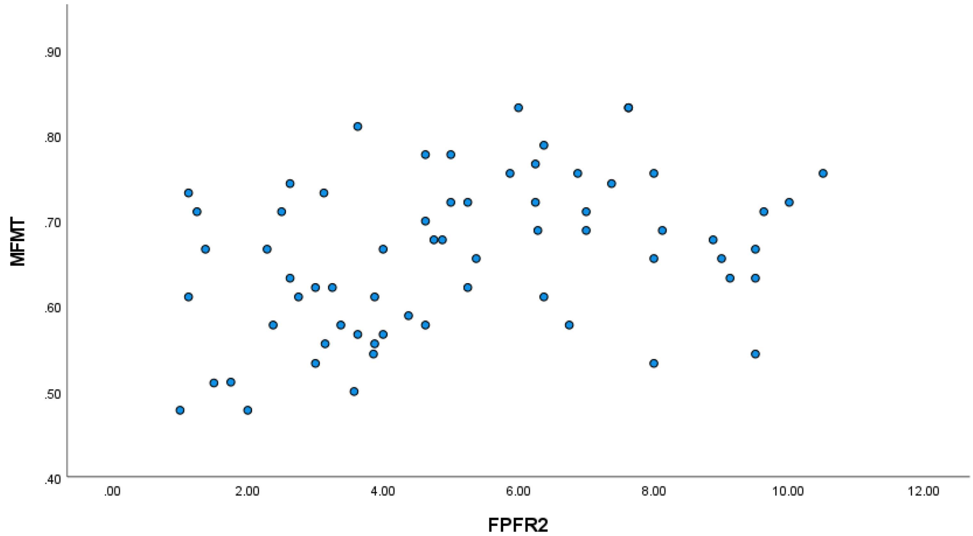

Figure 2. Scatterplot illustrating the positive relationship between FPFR2 (Physical Feature Scores) and MFMT Scores.

difference encoding ability are better at unfamiliar face recognition; 3) Semantic and facial features are not correlated.

The results indicate a positive effect of both semantic knowledge and physical facial feature encoding on unfamiliar face processing, as predicted by hypotheses 1 and 2. The relatively small Rs value (rs = .361) suggests that there may be at least one other factor that contributes to MFMT and that there may be a dominant effect for a certain factor related to semantic memory for novel face processing. However, a correlation was found between FPFR1 and FPFR2, rejecting hypothesis 3.

These findings are consistent with previous hypotheses that semantic information would benefit novel face recognition. The present study applied a different design to relate familiar face recognition in terms of semantic and physical facial features encoding with unfamiliar face matching, with a large sample size of both genders and a wide age range. The results suggest that people who have more semantic memories of familiar people perform better in recognizing unfamiliar faces, implying that people who are more interested in others perform better on unfamiliar face matching tasks. Additionally, people who can actively encode facial differences also benefit from having a better unfamiliar face recognition ability, suggesting that both abstract and surface encoding are involved in novel face recognition.

One unexpected finding was that semantic and physical facial features encoding abilities are significantly correlated. This could be due to underlying issues with the study design, or it might imply that semantic information and physical facial features are not completely

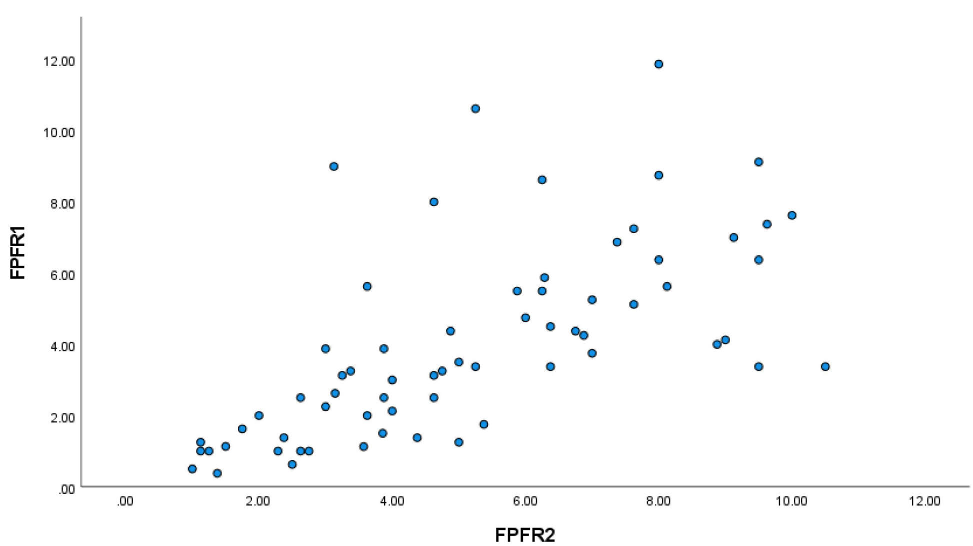

Figure 3. Scatterplot illustrating the positive relationship between FPFR1 (Fact Scores) and FPFR2 (Physical Features Scores).

separated, and there could be potential interactions between the two factors in the face network [9].

Besides, the study also provides valuable insights into the mechanisms underlying novel face recognition and suggests that both semantic and physical facial feature encoding play important roles in this process. However, future studies should further investigate the relationship between these two factors to better understand how they interact in the face recognition network.

5.2 Complexity of factors in unfamiliar face encoding

As a whole, the findings of this study not only highlight the complexity of multiple factors including semantic information and physical facial feature encoding for familiar faces involved in predicting unfamiliar face encoding ability but also suggest the possibility of face recognition is not a strict hierarchical or sequential process, but an interactive neural network with more complex patterns of connectivity among different areas and units.

According to existing models, it was assumed that the face-processing network is a hierarchical system organized in a feedforward manner and assessing the personal information of faces is a serial process, starting with the activation of face-related information and then identification occurs, and eventually, name-related semantic information is retrieved [25]. It is therefore assumed that there is little or no interaction between each processing stage. The sequential processing model of Bruce and Young [11] agreed semantic information retrieval takes place before naming [11]. In addition, sub-networks that specialized in specific face recognition and semantic memory retrieval are considered to be relatively independent processes [26].

Studies found semantic information was most likely to elicit the name when the occupation was already known than when the face was at first found unfamiliar or familiar only and majority of the participants recall the correct names for presented celebrities' faces is accompanied by successful recognition of the face and providing the occupation [27], consistent with the findings by Young et al. [28], of which no faces were named without the access of contextual information, and the face was always found familiar if contextual information was retrieved, indicating face recognition is feedforward process.

However, the foundational feature of the face-processing network is serial processing is questionable since the findings from the present study found a different pattern and positive correlation between semantic information and physical facial feature encoding ability for familiar faces. This indicates a potential interaction between surface encoding and abstract semantic encoding stages for recognition, agreeing with recent studies of which reported dissociation between naming and semantic retrieval during face recognition and a more complex pattern of connectivity among face network regions.

A two-stage network model (2000) proposed that OFA, fusiform area (FFA), and superior temporal sulcus (STS) are involved in the early visual processing of faces. Diversely, the extended system includes the anterior temporal pole (ATL), the amygdala, parietal and frontal areas, which is activated in higher-level cognitive processing such as semantic knowledge, and personality traits [29]. It was therefore assumed that information flows from the early visual cortex toward occipital face area (OFA), where face perception takes place, and then on to FFA for specific face recognition prior to the ATL, amygdala, and STS for higher-level processing such as identification and semantic knowledge retrieval.

Eick et al. [30] found occipital face area (OFA), which is involved in the construction of a low-level representation of the physical facial features, is also related to higher-level face processing. They applied an identity learning task and simultaneous disruption of face processing by transcranial magnetic stimulation (TMS) to test whether OFA is involved in the association of semantic encoding with a face and found stimulating the occipital face area (OFA) during encoding of face-related semantic information result in a reduction for correct recall of face-associated job titles [30]. This indicates that the causal role of the OFA in the association of familiar faces with related semantic information and semantic encoding of familiar face recognition is not limited to higher face-processing areas but involves the entire occipital-temporal network, which includes the OFA. Although this effect may be caused by the possible activation of adjacent areas of the face network during OFA simulation, it supports the idea that OFA is part of the network involved in higher face processing via probably recurrent feedback connection. This finding shows consistency with other studies, confirming OFA plays a significant causal role in the formation of identity-specific memory trace and face identity encoding [31], despite the lack of sufficient repetitions and general methodological limits of TMS study may impact the reliability of the conclusion.

The presence of significant effects of semantic knowledge and physical facial features encoded for famous faces on novel face recognition in this study supports studies that addressed face recognition networks involving lower-level and higher-level processing stages with complex patterns of connectivity. In line with reviews that offer dissociation and interactions between different areas for face processing stages, it may be worth considering that past experiments may be reporting stronger effects of visual encoding than are truly present, with other factors including semantic information encoding acting as mediators. Thus, it is important to reevaluate past research where these factors may have been involved but not identified.

5.3 Evaluations of design

There are challenges involved in the design of this study. Although attempts were made to be as rigorous as possible, a balance has to be struck between designing a simple enough task that allowed for the collection of a relatively large sample and collecting data that would allow reliable testing of the hypothesis. Therefore, some methodological points must be addressed in the consideration of the results.

First, there might be inaccuracy in the results since it is difficult to measure semantic memory precisely, and the different individual interpretations of the experiment may result in response ambiguity, which further impacts the quality of raw data in FPFR1 performance. Participants provided ambiguous responses that can be difficult to categorize into semantic or physical information, such as "sexy" and "hot," which are usually regarded as comments for appearance. However, some famous faces are well known because of these distinctive physical features due to the nature of their occupation, and whether it is a fact or physical feature depends on the subject's interpretations. Approximately 16.2% of participants wrote "sexy," "hot," "attractive" while providing semantic information in FPFR1. It is possible "sexy" or "hot" is interpreted as a physical feature when subjects perceive the famous face as sexually attractive during the presentation (i.e., look sexy from their appearance alone). Differently, "sexy" might also be semantic information of the familiar face when participants recall the presented face as being well known for high attractiveness (i.e., famous for being sexy). However, the crucial differences are not specified from these ambiguities because participants only wrote "sexy," therefore this ambiguity may cause inaccuracy in semantic memory responses.

In addition, the design used in the present study did not measure how accurately the semantic knowledge provided. Although incorrect facts might also aid semantic encoding, there may be situations in which the access to an incorrect semantic cue results in incorrect identification, such as mixing up similar semantic memories and leading to ambiguous responses, guessing, or even matching facts with incorrect faces. For the responses in FPFR1, a large proportion of participants reported they recognized the faces and found them familiar but unable to retrieve memory about them or unsure about the accuracy of the recalled information. Plus, four participants wrote guessed information such as "might be a singer," "probably likes dogs," and "probably like the gold color," and it is questionable about whether guessing answers can be considered as stored semantic knowledge, and the inclusion of these responses might add noises to the data.

However, this might have little impact on the results because it was found that when presenting an incorrect fact (i.e., a name or semantic information), the incorrect cue still leads to successful and accurate identification of the face, suggesting a relatively small amount of information is insufficient for destructing intact recognition [32]. Therefore, a serial task similar to Hodges et al. [] can be administered in future studies which include Famous face recognition, naming, verbal identification of un-named faces, cued naming using semantic and phonetic cues. Scores are calculated for the overall total correction and for each task in test conditions so that a more precise semantic memory score can be obtained.

Apart from these, names and other semantic information can be encoded separately, and the inclusion of naming in "facts" for FPFR1 may cause inaccuracy in semantic memory measurements. Because names and semantic retrieval are different stages for face processing [11], the facilitating effect of semantic memory of familiar faces on novel face recognition could be affected by the difference between naming and semantic information processing. A study investigates face recognition, naming, and verbal identification using semantic and phonetic cues on patients with dementia of Alzheimer type (DAT) found semantic cueing did not aid naming performance; however, DAT patients benefit from phonemic cueing suggesting store of famous names partially remains or even intact in some cases despite the loss of semantic knowledge []. This provides indirect evidence for a dissociation between semantic retrieval and name retrieval and indicates that name production and semantic information access can operate distinctly in a face recognition system.

In contrast, accessing the semantic knowledge of famous people from faces and name identifications seems to rely on a common pool of semantic knowledge [33]. A study by Hanley & Cowell [27] discovered a large proportion of participants provided the names and claimed not knowing the celebrity's occupation, always successfully guessed the correct occupation, suggesting subjects had accessed contextual information about the famous face concerned before recalling the name. On some occasions when faces were named without being found familiar, the occupation was known or correctly guessed before the names were given [27]. However, it is possible that the observed effect may be attributed to limitations in the design used. Despite the mixed evidence found, future research applying a different design to separate the name and semantic retrieval while collecting responses would give further clarity of the found facilitating effect of semantic information.

Another potential limitation of the current study is that the significant correlation between facts and physical features might reflect attentiveness in the task. It is likely people putting in more effort, in general, would perform better for both FPFR 1 and FPFR 2 and MFMT because they are more engaged. This could result in inaccuracy in the number of responses collected. Thus, future studies could improve by including an additional task to assess attentiveness.

There could also be a potential connection between facts and physical features provided due to the nature of famous faces. It can be argued that certain careers may require distinctiveness, especially for movie actors and singers that are well known for being attractive. Facial distinctiveness operates differently for unfamiliar and familiar faces. For unfamiliar faces, distinctive faces are subsequently recognized with higher accuracy than those rated as typical. For familiar faces, those rated distinctive are recognized faster than those rated typical [34]. The stimuli used for this study include four singers, three actors and actresses, and one politician. It is probable that this large proportion of famous actors and singers with stimuli results in higher FPFR2 scores and reflects an inaccuracy for their average physical feature encoding ability.

In addition, semantic memory tests using autobiographical information for famous faces or knowledge of events may depend upon quite different aspects of memory. It was argued that the same biographical memory tests for famous faces might access different memory stores depending on the date from which the test material is drawn; an event or face from early life might be remembered more as an item of general semantic knowledge, while a comparable event from the more recent past might still be recalled as a personal episodic memory [35–37]. In other words, repeated rehearsal pre-exposure over many years results in memories that are initially episodic transforming to part of semantic memory. This study includes both episodic and semantic memory for famous faces, but the two types of memories can be encoded differently. Future studies could apply more precise instructions to further improve the accuracy of semantic knowledge encoding ability.

Another general methodological constraint, which limits the result interpretation is that correlational study only assesses the strength and direction of relationships between semantic knowledge, physical feature encoding, and novel face matching, but does not entail causality.

Any combination of the issues described above may be regarded as weakening the validity of the effects that were measured in this experiment. Nevertheless, as is discussed in the previous section, the findings are still consistent with the present state of the literature to an extent. Rather than discounting the findings of the present paper and any other studies that suffer from the same methodological issues, these difficulties highlight the overall challenge of studying factors difficult to measure objectively with a high level of accuracy such as semantic memory for familiar faces.

6. Conclusion

In conclusion, these findings suggest that encoding of semantic knowledge and facial features may facilitate face identity processing to a moderate level. Moreover, this study highlights the potential for physical facial feature encoding to be associated with semantic retrieval, indicating the possibility of multiple aspects of face-perception ability to contribute to novel face recognition processes via a complex face network. However, further research is needed to fully understand this network. Future studies could include measuring participant attentiveness, investigating differences between naming and semantic retrieval performances, and applying a serial recognition task to better measure semantic knowledge. These efforts could provide further clarity on the face-processing system and potentially provide evidence for the pattern of face network connectivity.

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Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author contribution

Conceptualization, Y.Q. and Y.L.; methodology, Y.Q.; validation, Y.Q. and Y.L.; formal analysis, Y.L.; investigation, Y.Q.; resources, Y.L.; writing – original draft preparation, Y.Q.; writing – review and editing, Y.Q. and Y.L.; visualization, Y.Q.; supervision, Y.L.; and project administration, Y.L. All authors have read and agreed to the published version of the manuscript.

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