

The effect of the strategic facial processing on familiar face recognition in adults

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Abstract

Experimental research highlighted an essential role of strategic facial processing in facilitating the recognition of familiar faces. This research questioned the same effect in a sample of 26 university students aged 19-36. It was hypothesized that using different strategies of facial processing will be reflected in different reaction times and that subjects who rely particularly on physical feature processing strategy will have longer fixation gazes on familiar faces than those who do not. 18 females and 8 males completed a face recognition task. Their reaction times and fixation lengths were recorded through an eye-tracking system. The hypothesis was not supported as there was no significant difference among participants who used featural processing strategy, similarity-based or stereotypical strategies and the other group. An independent samples t-test also indicated no significance between the fixation time of participants who used featural processing and others who did not. These findings challenge the existing evidence on the significant effect of strategic processing of faces in predicting familiar faces recognition and call for further research to question this topic while considering the overlooked strategies in the literature.

Keywords: Face Recognition task, Strategic facial processing, Reaction times, Fixation length, Independent Samples t-test.

The effect of strategic facial processing on face recognition task performance

Being an essential element of human interaction and communicating with others efficiently, face recognition is the cognitive process in which an individual is able to distinguish faces of familiar people through a presented image or visual contact with them (Puce, 2001; Lopatina et al., 2018). Recognizing faces was specifically found to be different from other ocular recognition abilities provided that it is heavily rooted in distinctive cognitive processing of the visual stimulation when compared to the computation of other abstract imagery (McKone et al., 2007; Duchaine & Yovel, 2008; Wilmer et al., 2012). It was also highlighted as one of the differential cognitive capacities significantly influenced by genetic inheritance, which can be regarded given the flow of Prosopagnosia disorder among members of the same families (Schmalzl et al., 2008; Wilmer et al., 2010). Nevertheless, facial recognition was reviewed as a very specific aptitude of variation among individuals that is not merely limited to a genetic element or dispositional qualities but can also be influenced by several external factors that relate to the input image or facial features (Wilmer et al., 2014). According to the face space theory, identifiable faces are mentally sketched in a psychological "multidimensional space" based on the characteristics that feature them (Valentine et al., 2016). Ellis et al. (1979) studied the sensitive role played by the facial feature type; being an internal or external feature, in differentiating familiar and unfamiliar faces. Based on their findings, attending to the internal facial features including the eyes, mouth and nose becomes more important in recognizing familiar faces than dealing with the external features such as the hair and the facial shape or shape of the head. This gets to be manifested in a robust representation of the recognized familiar face in the facial memory unlike the case of perceiving unfamiliar faces wherein the processing of both internal and external features come into play (Young et al., 1985). In a review of

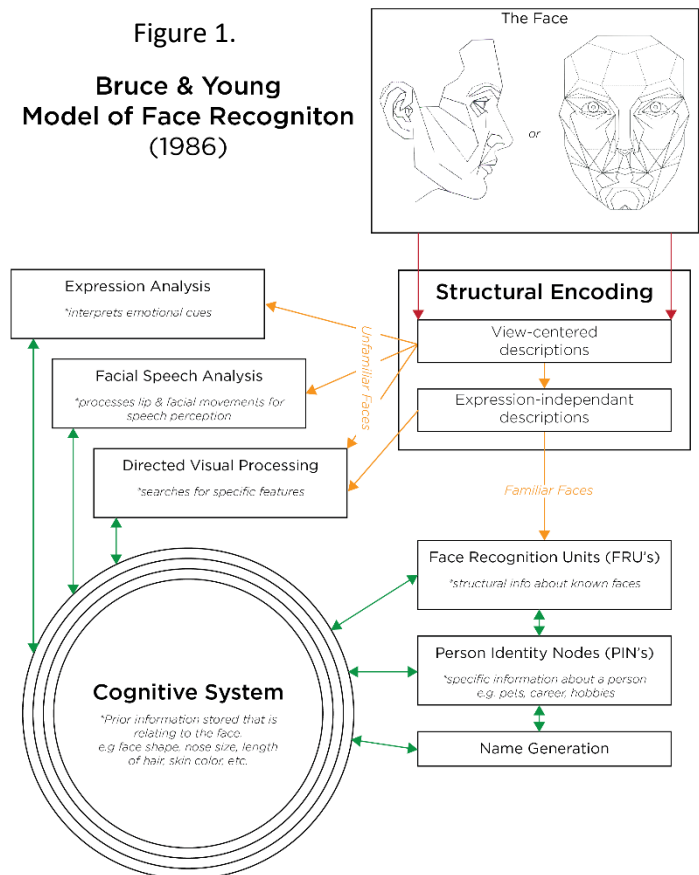
previous experiments conducted on the recognition of familiar versus unfamiliar faces, utilizing a range of “Recognition Memory Paradigms”, Bruce and Young (2012) made a distinction between the photograph or image recognition and face recognition abilities. They indicated that people tend to master the recognition of unfamiliar images by selecting the photographs they viewed out of those they didn’t. Nevertheless, humans have a more limited capacity for recalling unfamiliar faces when being subjected to recognize a different image of a previously seen face. Thus, recognizing one’s face turns out to be connected with several cues including the face perceiver, the perceived features of the target face in addition to the degree of face familiarity. In this regard, face recognition has grown a subject of vast research that utilizes different sets of tasks for modeling this process in humans (Tolba et al., 2005; Duchaine & Yovel, 2008). Models of face recognition distinguish between the specific recognition of faces and the other complimentary facial processing tasks. For example, the face verification task assesses the ability to relate between a facial image and its owner (O’Toole & Abdi, 2001). Among these tasks also is face identification which differs from face recognition in the cognitive aspect of processing faces. While face recognition stands for the ability to identify familiar faces, face identification deals with bringing back the relevant details to a person’s face such as a name or situational acquaintance; both of which tasks examine the extent to which a perceived face is distant from a recognizable one in the face space (O’Toole & Abdi, 2001). In order for this identification to take place, an individual firstly goes through a processional system of facial recognition that encompasses a series of neurocognitive mechanisms beginning with the neural encryption of the perceptible image, identifying the basic facial features, fixing and systemizing the facial size, minimizing the dimensions of the neural correlates, ending with the comparison between the formed facial image with the existing representations in the memory trace (Baron, 1981).

According to the two-way model of face processing suggested by Bauer (1984), there are two different approaches through which face recognition in Humans can be addressed; neuroanatomical and cognitive systems. This study focuses on the cognitive stream of facial processing and the potential cognitive strategies that are utilized for the ease or functionality of this process.

The cognitive basis of face recognition

One of the previously developed paradigms by Bruce and Young (1986) predicts the occurrence of face recognition within a one-route model of four successive stages that portray the cognitive pattern of facial processing (see fig 1). The initial stage covers an analysis for the facial “descriptions” including race, gender, race, age, facial expression and speech. This process is also known as “structural encoding” in

which an integrated processing of the face and its features is executed (Bruce & Young, 1986). Next, the recognition of faces’ familiarity takes place wherein the perceived familiar faces match their cognitive representations that are known by “Face Recognition Units” (FRUs) (Etchells et al., 2017). Following this stage is a complementary treat in which the previously described process of facial identification is facilitated through the retrieval of the semantic data and the



information, that relates to the familiar person's biography and identity, stored in specific memory records known by "Person Identity Nodes" (PINs) as described by Barton and Corrow (2016). The last stage incorporates the automatic running of name generation for the identified person and the recall of other characteristics that pertain to the recognized face. Name generation, however, has been considered to be a different process by researchers provided that it relies on retrieving verbal information instead of an observation or experience-based information, and hence, engaging a different part of the perceiver's memory (Baron, 1981).

Another study by Ellis and Young (1990) has put forward a two-route model that emphasizes how face recognition occurs through two complementary pathways. One of them is specialized for the ocular face recognition and the other route deals with the affective reaction in case of recognizing a familiar face. By referring to the difference between subjects with Prosopagnosia and others diagnosed with Capgras' syndrome in their research, Ellis and Young were able to show the distinction between these two routes, wherein Prosopagnosia patients are indicated to suffer a deficient functioning of the ocular face recognition route as opposed to Capgras' syndrome patients who put up with impairments in the affective track. Furthermore, Breen et al. (2000) built on Ellis and Young's model, suggesting that the two routes are independently branched from the same FRU, with the face recognition pathway connecting to the PIN for identifying the recognized person and the affective route in charge of the emotional reaction. According to their cognitive model, after matching the familiar face image with its cognitive representation, there is a concurrent access to the facial identity in the PIN and emotional feedback, which was reported to be higher in response to recognizing a familiar face in comparison to perceiving an unfamiliar face. Overall, different studies have introduced variant models of face recognition while attempting to put emphasis on the associated semantic and

affective processing that accompany this cognitive encoding of facial stimuli. In spite of the similarity in the cognitive patterns of facial processing that can be recorded among human beings, people might use different strategies to remember faces, which can also be expressed in different performance on the face recognition task, reflecting different capacities of recognizing familiar faces.

Facial encoding strategies

To begin with, one of the broadly acknowledged and studied aspects of strategic face processing that humans have developed for perceiving and recognizing faces is the holistic processing strategy (Farah et al., 1998; Griffin & Motta-Mena, 2019). When the facial features of others are processed holistically, they are strongly encoded into integrated and uniform wholes or “gestalts” that are then represented as “face templates” (Tanaka & Farah, 1993; Rezlescu et al., 2015). Among the used measures of face holistic recognition is the established “part/whole task” which is based on assessing the difference between recognizing facial features separately and as parts of a whole face. This task underlines the influence of holistic processing on facial encoding in the short-term and long-term memory as it makes a distinction between two conditions of memorizing facial features; holistically in integration with the entire perceived face during the learning task, or recalling faces in reference to a distinct feature such as the shape or size of a nose (Tanaka & Simonyi, 2016). Based on the findings of previous research, participants’ recognition of the learned facial features was significantly higher when those features were integrated into a whole face compared to their independent recognition of face parts (Tanaka & Farah, 1993; Tanaka & Simonyi, 2016). It was also indicated by Tanaka and Simonyi that humans’ memories of the whole face enclose their memories of the facial features, but this doesn’t necessarily hold true conversely. Despite being acknowledged as a ground for

understanding face recognition in humans (Richler et al., 2011), the holistic recognition of faces has been argued to be not the most reliable strategy provided that its functionality significantly decreases or ceases to exist by introducing some manipulations including inversion of faces (Rossion, 2009). Furthermore, its role in familiar face recognition remains passive in contrast to the non-holistic feature-based processing which gained a genuine interest by researchers in terms of its relation to the capacity of recognizing familiar faces (Mohr et al., 2018). In light of this, Visconti di Oleggio Castello et al. (2017) conducted a study on 19 male university students at Dartmouth College to examine whether the featural processing of faces makes it easier to recognize familiar faces in various orientations (upright and inverted). Participants took part in a face recognition experiment wherein the familiar faces were images of their friends and they were asked to identify a target face (an unfamiliar face or friend's face) in the presence of distractor faces, presented straight up and overturned on different trials. Results showed that the subjects had shorter reaction times for recognizing both upright and inverted friends' faces than their response time for identifying the unfamiliar faces in both orientations. The findings of this study highlights the role of processing regional face features in guiding the successful recognition of familiar faces, considering the previous account for the "face inversion effect" (Rossion, 2008) which was indicated to stimulate non-holistic (featural) processing of face and distort the holistic processing of faces. Supporting these results, van Belle (2010) found that people are more likely to process the individual facial features of familiar people than those of unfamiliar persons. Furthermore, a study by Van Belle et al. (2010) highlighted the importance of processing facial features for face identification in Prosopagnosia patients, who suffer deficits in processing faces holistically, using eye-tracking techniques wherein higher number of fixation gazes and saccades were recorded in the featural-processing-stimulating condition compared to

that of the “full view” facial presentations. Another stream of research focused on the function of stereotype-based strategy of facial processing in facilitating unfamiliar face recognition. One of experimental researches done by Hills et al. (2008) revealed that attributing stereotypes to faces serves the recognition of unfamiliar faces. In their research, this effect was traced back to the semantic labels associated with the stereotyped faces which strengthen the encoding of them in facial memory.

The results of the above-mentioned suggest that different facial processing strategies predict different face recognition abilities, and that some strategies are more efficient predictors of familiar/unfamiliar face recognition, in course of speed and accuracy, on the face recognition task. Moreover, some of these facial processing strategies are modeled to be functioning in a complementary framework or to come in sequence wherein part-based and holistic processing occur shortly after each other as indicated by the dual-route model (Wang, 2019). Still, further research is needed to address this topic given the shortage in literature. For example, the majority of studies focused on holistic processing as well as the individual processing of physical features. Very few studies looked into the effect of stereotypical processing of faces and other strategies like attributing similarity to faces based on acquaintances or association. This study aims to cover some of the previous studies' limitations by highlighting the potential differences between some of the facial processing strategies; namely physical feature processing strategy, stereotypical processing strategy and similarity-based strategy, in predicting familiar face recognition.

Hypothesis:

It is hypothesized that:

1. Participants with different strategies for facial processing will also exhibit different latencies in recognizing familiar faces.
2. The more the participants use physical feature processing strategy, the longer their fixation time will be on familiar faces compared to those who do not use it.

This was previously supported by the results from Van Belle et al. (2010) study which showed that featural processing is associated with higher records of fixation gazes on familiar faces compared to the condition of automatic holistic processing.

Method

Participants

The participants taking part in this experiment were reached through convenience sampling. Only Hungarian students who are native Hungarian speakers at the University of Pecs were invited to participate in the experiment. The sample consisted of 26 adults ranging in age from 19 to 36 years old and the average age of the participants was 22.3 years ($SD = 4.35$). There was no formal calculation for the power estimate to determine sample size, but the aim was to secure a sample size that comprises at least 15 participants. The sample was not balanced with respect to gender given that 8 males and 18 females completed the experiments. A high proportion of the sample was represented by females (69.2%) whereas males represented only 30.8% of the entire sample. Participants were financially compensated for their participation in the study. Participants were financially compensated by 5000 Hungarian Forints as an acknowledgement of the time and effort they exerted for participating in this research study.

Materials

Face recognition task

A face recognition task, that was programmed and designed using PsychoPy software, was used to assess different dimensions of measurement in the facial recognition experiment including the participants' recognition speed, fixation time and saccades before and after pressing the buttons among different blocks with different sets of measurements. At first, participants are presented a welcome text and information about the task. Secondly, a practice block takes over wherein the subjects watch animal faces with their labels, presented after each other, and then complete a task by pressing the right or left button while matching the label with the correct animal picture. This is followed by a learning task in which 17 faces paired with their occupation labels are adjusted beforehand to stereotypically match each other based on previous research (Kocsor et al., 2021). Pictures are watched in a random order and each face is repeated five times during the learning task. Each face is presented from two to three seconds. Following the learning task is Block 1 that deals with the "familiar vs unfamiliar face" condition. In each trial, one of the presented faces is the familiar face which comes in different conditions; either in congruent pairs wherein the face is presented along with its matching label that was shown in the learning task or the case of incongruent pairs in which the face is presented with an incorrect label that differs from the initial label in terms of distance. For example, the false label could be semantically and affectively approximate to the original label, semantically approximate but affectively distant, semantically distant but approximate on an affective level or both semantically and affectively distant from the initial label. The other face represents the unfamiliar face. In this block, there are 85 pairs of faces and 15 distractors presented across 100 trials. It is worth mentioning that in the first block of this task, the semantic distance is between the faces and the occupational

labels/stereotypes, unlike the second block in which the distance is between the images themselves. In other words, Block 1 concerns how distant the two presented faces are from the label, whereas Block 2 considers how distant the two presented faces are from each other on a semantic level. There are twenty pairs and thirty-two distractors while the third block comprises thirteen pairs of faces plus forty-five distractors. Faces are repeated merely twice in the learning tasks that precede the second as well as the third block. The face recognition task takes approximately 50 minutes to complete.

Anonymous questionnaire

An anonymous questionnaire was given to the participants as a kind of post-test to assess whether the participants paid attention to remember the faces by using any strategies of facial processing or not. In this questionnaire, participants are asked to indicate which strategies they might have used for recognizing familiar faces. For instance, among the items is “I didn't try to remember the faces” indicating that the participant did not use any strategy, “I observed the visible features of the face (eye color, nose, mouth, etc.)” showing that one relies on physical feature processing strategy. Others like “I tried to compare the faces to people I knew”/ “I tried to associate names with the faces”/ “I tried to remember them by their occupation” or “I recalled people I knew who had the same occupation” signals that they use a strategy of attributing similarity to personal acquaintances. Equally important, items such as “I tried to imagine how they might behave in real life” / “I tried to guess what their personalities might be like” or “I tried to imagine what it might feel like to talk to them” indicate that the participant uses a stereotype-based strategy to remember faces. An “Other” item was included in the questionnaire to allow the subjects to indicate if they relied on a different strategy from the above-mentioned ones.

Procedure

Participants were informed about the objectives of this study and ethical procedures. They were sent a spreadsheet to choose among the available slots (two hours per each) for the experiment which took place in the eye tracking lab at the institute of psychology, University of Pecs.

Participants were briefly informed about the details of the experimental setting that there will be two experiments, both of which use eye-tracking data, at first, they have to complete a face recognition task and on the other task, they will be required to search websites and give their evaluation to them. They were also informed about the time of completing the task, the financial compensation amount, and the personal information to be provided for this, including the Bank account number and tax registration number, then they were given the contact details of the researcher for sorting out the arrangements. Confidentiality and information protection were ensured. On the experimental days, participants were accompanied by the experimenter to the computer lab, seated to start the task in a separate room from the experimenter's eye tracking laboratory. Firstly, they started the face recognition task reading the initial instructions, completing the practice task and then the learning task. In block one, they were viewed with the instruction "press left or right button if you recognize a face" and their reaction time was recorded as they went through the trials. Throughout the experiment, the presentation of faces and labels was counterbalanced; given that the face appearance was randomly manipulated among left and right corners on the screen. Additionally, distractors or "extra stimuli" were used to balance the occurrences of the target pictures. These distractors included both familiar and unfamiliar faces displayed with random labels in pairs among the three blocks. There was no record of the answers to the distractors and they were not needed. Moreover, the order of the presented labels and faces themselves was randomly assigned in each block. Furthermore, the

presentation of every face and label in total was six times from the first to the third block of the task. An eye-tracking software was used to keep a record of the eye movements, saccades, and fixation gazes of the participant at a sampling rate of 300 Hz (one recording every 3.3 milliseconds). After completing the face recognition task, participants answered the questionnaire on the strategy to remember faces. Participants were then thanked for their participation and those interested in the results of the study were informed at the end of the research. Jamovi statistical spreadsheet was used for data analysis.

Results

Four independent Samples T-test (tests were then corrected to the non-parametric equivalent; Mann Whitney U test because of violation of normality) were applied to analyze the collected data and compare the facial processing strategies used by participants in terms of reaction times and fixation gazes' length on familiar faces. The mean reaction time for those who used physical feature processing strategy (Mdn = 1.03, Range = 0.81) was not significantly different from those who did not use it (1.08, 0.32). The median difference (look up fig.2) was (0.068, 95% CI [-0.17, 0.27] ($U = 28$, $p = 0.64$). This was seen to have small effect size $d = 0.188$. These statistics show that using featural processing of faces does not notably differ from not using it in predicting faster response on the face recognition task. Comparably, the mean response time for the participants who relied on similarity-based strategy (Mdn = 0.98, Range = 0.8) did not significantly differ from those who did not use it (1.1, 0.1) with a median difference (see fig.3) equals (0.11, 95% CI [-0.15, 0.24] ($U = 20$, $p > 0.05$). The effect size was of medium relative size $d = 0.42$. These statistical results indicate that attributing similarity to personal acquaintances while processing faces of others does not significantly contribute to a faster

recognition of familiar faces. Similarly, there was no significant difference in the mean reaction times between subjects who counted on stereotype-based strategy of facial processing (Mdn = 0.98, Range = 0.47) and the other participants who did not use it (1.07, 0.78). The median difference (look up fig.4) was found to be (0.05, 95% CI [-0.05, 0.2] ($U = 56$, $p > 0.05$). This was noticed to have small effect size $d = 0.27$. Accordingly, the stereotypical processing of faces was found not to meaningfully differ from the condition of not using it in terms of recognizing the familiar faces faster on the face recognition task. Finally, an independent samples t-test was used to compare the fixation length for participants who used a physical feature processing strategy and those who did not. The fixation length of subjects who used featural processing (Mean = 117543, SD: ± 38093) appeared to be lower than that of the other participants who did not rely on it (Mean = 120284). This difference (2741, 95% CI [-77958, 83441] however was not significant $t(22) = 0.07$, $p > 0.05$), showing that the fixation time difference between the two participant groups is not meaningful and that the fixation length of participants who use featural processing was not even longer.

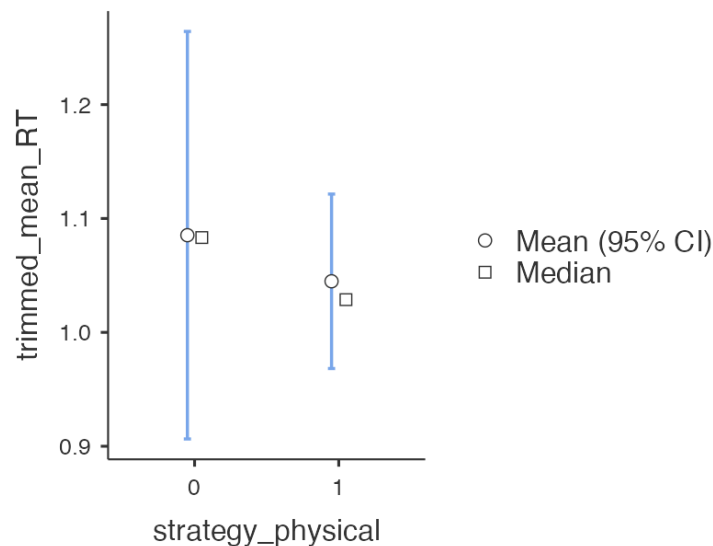


Figure 2. Shows the median difference between the groups who used featural processing strategy and those who did not

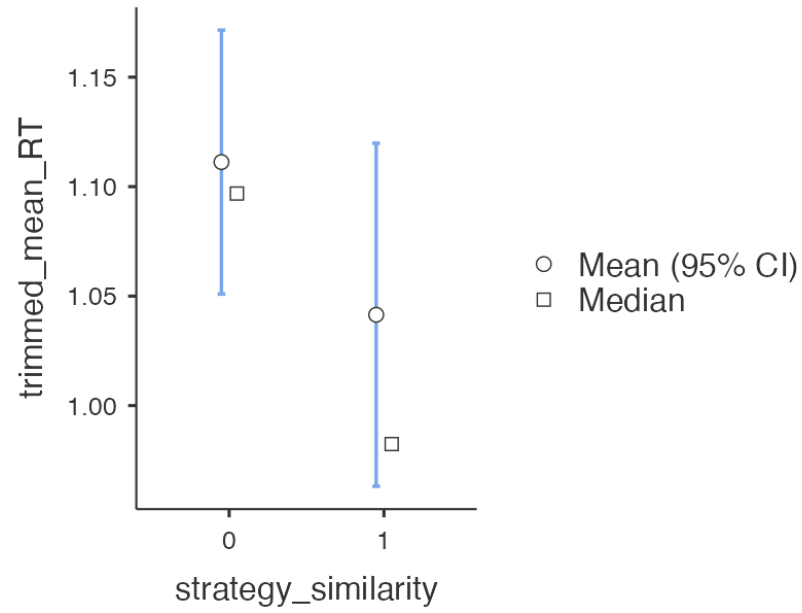


Figure 3. Shows the median difference between the groups who relied on similarity-based processing and those who did not

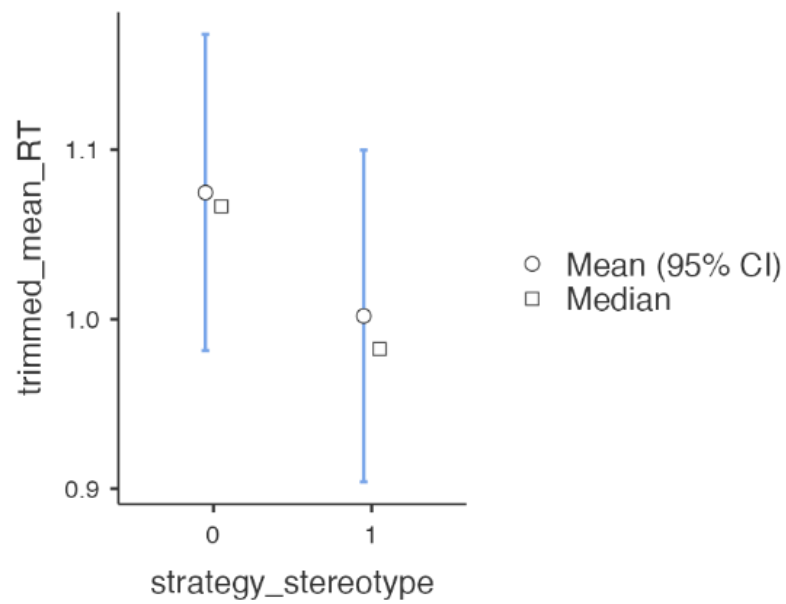


Figure 4. Shows the median difference between the groups who used stereotypical strategies and those who did not

Discussion

The findings of this study did not support any of the hypothetical assumptions provided that participants who used different strategies for facial processing, whether feature-based processing strategy, stereotype-based or similarity-based strategies for facial processing, did not significantly differ or press the button considerably faster than those who didn't use these strategies when recognizing familiar faces. Using physical feature processing strategy was also not found to predict longer fixation time on familiar faces than the case of not using it. On the contrary, the fixation length associated with not using this strategy was even longer.

Accordingly, these results correspond to a minor effect of strategic facial processing in addressing familiar face recognition. These results contradict the findings of previous research by Visconti di Oleggio Castello et al. (2017) that was mentioned earlier and which highlighted the outstanding relationship between the recognition of familiar faces and physical feature processing. According to their records, participants had less reaction times for recognizing inverted-familiar faces, relying on physical feature processing, than that of unfamiliar faces. Another experimental research conducted by Ellis et al. (1979) supported these findings revealing that the processing of internal or external features of faces did not seem to affect the recognition of unfamiliar faces in contrast to the identification of famous familiar faces that was found to be facilitated by processing the internal features of these faces. However, it was found by Hills et al. (2008) that the stereotypical processing of faces contributes to recognizing the unfamiliar faces, with no emphasis on how this effect could be addressed in terms of familiar ones, which was not supported by the results of research either. This implies an essential differentiation between effects that can be noticed in response to unfamiliar faces and those

elicited by recognizing familiar faces, both of which effects do not necessarily generalize to each other as indicated by Mohr et al. (2018).

Given the limitations of my experimental design, it should be pointed out that the obtained results might have been influenced by the small sample size, that could have a strong influence on some issues including, the violation of normal distribution of the data and the assumption checks, in addition to the non-significance of the applied tests. Another issue concerning the limited sample size was the unbalanced counts of the compared groups as only three subjects did not use featural processing compared to twenty-three others who did, which calls into question the validity of these results. Besides, the lack of recorded data for two of the participants who did not use physical feature processing strategy in terms of their fixation lengths resulted in comparing the data of only one participant with no featural processing to twenty-three others who made use of this strategy, which made it very difficult to validly test the second hypothesis. Despite these limitations, this research can be used to draw some inclusions that would benefit future research in this area such that a greater sample size should be counted. Future research is recommended to investigate the overlooked facial processing strategies including similarity-based and stereotypes-based strategies, and to address more specific research questions on the effect of processing internal or external features of the face. Given that the strategies addressed in this research were not mutually exclusive; meaning that participants did not only rely on one strategy but used more than one strategy to remember the familiar faces (corresponding to the dual-route model of Wang (2019)) presented in the learning task, it was not possible to compare whether the dependence on one strategy predicts better performance on the face recognition task in terms of recognizing familiar faces. Hence, it is suggested to consider this issue in a matching experimental design. On the other hand, it sheds light on another stream of research that brings

into question how the reliance on multiple strategies of facial processing could predict more efficient recognition of familiar faces in comparison to using one strategy. It is also worthy to mention that the type of statistical analysis used in this research was restricted by the above mentioned non-mutual exclusiveness between the facial processing strategies. For this reason, multiple t-tests were applied instead of ANOVA because the usage of a particular strategy was not independent from using other strategies and hence, could not be compared independently. Nevertheless, this analysis might have brought about a higher rate of type I error with the obtained results. Therefore, prospective researchers are suggested to improve this analysis in order to control these types of errors and ensure that an obtained statistical significance is not affected by such error rates. Future research in this area is also recommended to involve or consider other factors that can affect the participants' attentional performance such as the caffeine dependence and sleeping hours. Finally, improving the face recognition task concerning the time it takes to be completed represents a critical issue to consider in the interest of ensuring that participants do not lose their motivation or grow tired as they go through the same tasks for a long time, which also contributes to improving the internal validity of the research.

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