Cognition 181 (2018) 12–20

Contents lists available at ScienceDirect

Cognition

journal homepage: www.elsevier.com/locate/cognit

Original Articles

Greater reliance on the eye region predicts better face recognition ability

Jessica Royer[a], Caroline Blais[a], Isabelle Charbonneau[a], Karine Déry[a], Jessica Tardif[b], Brad Duchaine[c], Frédéric Gosselin[b], Daniel Fiset[a,*]

[a] *Département de Psychoéducation et de Psychologie, Université du Québec en Outaouais, Canada*
[b] *Département de Psychologie, Université de Montréal, Canada*
[c] *Department of Psychological and Brain Sciences, Dartmouth College, United States*

A R T I C L E I N F O

Keywords:
Individual differences
Face recognition
Face perception
Bubbles

A B S T R A C T

Interest in using individual differences in face recognition ability to better understand the perceptual and cognitive mechanisms supporting face processing has grown substantially in recent years. The goal of this study was to determine how varying levels of face recognition ability are linked to changes in visual information extraction strategies in an identity recognition task. To address this question, fifty participants completed six tasks measuring face and object processing abilities. Using the Bubbles method (Gosselin & Schyns, 2001), we also measured each individual's use of visual information in face recognition. At the group level, our results replicate previous findings demonstrating the importance of the eye region for face identification. More importantly, we show that face processing ability is related to a systematic increase in the use of the eye area, especially the left eye from the observer's perspective. Indeed, our results suggest that the use of this region accounts for approximately 20% of the variance in face processing ability. These results support the idea that individual differences in face processing are at least partially related to the perceptual extraction strategy used during face identification.

1. Introduction

Face identification is a great challenge for the visual system, as human faces consist of a small set of facial features (e.g. the eyes, the nose, the mouth) with only subtle variations in inter-attribute distances (Dupuis-Roy, Fiset, Dufresne, Caplette, & Gosselin, 2014; Taschereau-Dumouchel, Rossion, Schyns, & Gosselin, 2010; see also Burton, Schweinberger, Jenkins, & Kaufmann 2015; Sandford & Burton, 2014). In the last few decades, the processes supporting face identification have been extensively investigated using group-based approaches where interindividual variations were typically regarded as uninformative noise. However, significant variations in face identification ability have been observed within the healthy population (Bate, Parris, Haslam, & Kay, 2010; Bowles et al., 2009; Duchaine & Nakayama, 2006; Royer, Blais, Gosselin, Duncan, & Fiset, 2015; Wilmer et al., 2010), and many authors now highlight the importance of individual differences to gain a better understanding of face processing mechanisms (e.g. Yovel, Wilmer, & Duchaine, 2014; see also Richler, Cheung, & Gauthier, 2011 for a discussion).

An example of this growing interest for individual differences is found in recent papers studying holistic processing, i.e. the extent to which individuals integrate facial parts into a unified whole or "gestalt" (Farah, Wilson, Drain, & Tanaka, 1998; see Richler, Palmeri, & Gauthier, 2012 for precisions regarding the measures and subtypes of holistic processing). The experimental effects thought to measure holistic processing (e.g. composite effect, Young, Hellawell, & Hay, 1987; part-whole task, Tanaka & Farah, 1993) have been replicated numerous times at the group-average level (see Richler et al., 2012). However, if holistic processing is indeed important for face processing and identification, individual differences in the ability to discriminate and recognize faces might be expected to at least partly depend on this mechanism. Results addressing this question are mixed: While some have obtained a significant correlation between face recognition ability and the magnitude of certain experimental effects thought to reflect holistic processing (DeGutis, Wilmer, Mercado, & Cohan, 2013; Richler et al., 2011; Wang, Li, Fang, Tian, & Liu, 2012), others have not (Konar, Bennett, & Sekuler, 2010; Richler, Floyd, & Gauthier, 2014). Moreover, studies finding a link indicate differences in holistic face perception only account for a limited proportion of differences in face recognition ability. We thus believe it is important to investigate other perceptual

* Corresponding author at: Département de Psychoéducation et de Psychologie, Université du Québec en Outaouais, C.P. 1250, succursale Hull, Gatineau, Québec J8X 3X7, Canada.
E-mail address: daniel.fiset@uqo.ca (D. Fiset).

https://doi.org/10.1016/j.cognition.2018.08.004
Received 30 May 2017; Received in revised form 3 August 2018; Accepted 6 August 2018
0010-0277/

and cognitive mechanisms known to be involved, on average, in face recognition using an individual differences based approach.

Here, we explore the hypothesis that the visual information extracted during face recognition is systematically related to face processing abilities. In line with this proposition, Pachai, Sekuler, & Bennett (2013) demonstrated that tuning for horizontal information is significantly correlated with upright face identification accuracy as measured within the same recognition task (see also Pachai, Sekuler, Bennett, Schyns, & Ramon, 2017). To our knowledge, this is the first study to show a clear link between the use of specific low-level visual information (i.e. perceptual strategies) and face recognition ability. However, based on these results, we cannot disentangle whether the best face recognizers are especially sensitive to horizontal information itself or to certain features that contain greater amounts of this type of information, for instance the eye area. Indeed, past research investigating visual information extraction strategies in face identification using group-average approaches have repeatedly demonstrated that the eye region is crucial for the correct identification of facial stimuli (Bentin, Allison, Puce, Perez, & McCarthy 1996; Butler, Blais, Gosselin, Bub & Fiset, 2010; Caldara et al., 2005; Gosselin & Schyns, 2001; Itier, Alain, Sedore, & McIntosh, 2007; Sekuler, Gaspar, Gold & Bennett, 2004; Vinette, Gosselin & Schyns, 2004; Xivry, Ramon, Lefevre & Rossion, 2008). Although this result sheds light on the nature of the most diagnostic facial feature in the healthy population, it may hide important individual differences in the visual strategies used to process faces. Indeed, the average perceptual strategy used by a group of observers may not necessarily predict the use of information in the most skilled individuals in a given task. For instance, previous results show that the mouth region (Blais, Roy, Fiset, Arguin, & Gosselin, 2012; Calvo, Fernández-Martín, & Nummenmaa, 2014) and tuning for horizontal information (Balas & Huynh, 2015; Duncan et al., 2017; Huynh & Balas, 2014) are particularly diagnostic for the task of facial expression categorization. However, recent evidence suggests that individual differences in utilization of horizontal information were predicted by the diagnosticity of the eye area, and not the mouth (Duncan et al., 2017). In the case of face recognition, if the eye area is indeed important (or diagnostic) for face recognition in human observers, we should expect that the individual observers that are especially skilled in face processing rely on this strategy to a greater extent than individuals with weaker face processing ability. Other types of information such as spatial frequencies (SFs) may also be associated with face processing ability. Although low SF information is not used, on average, by human observers, ideal observers are able to make use of this information (see for example Gold, Bennett, & Sekuler, 1999; Näsänen, 1999). On the other hand, the use of horizontal orientations in face recognition appears to be subtended by mid-to-high SFs (Goffaux, Van Zon, & Schiltz, 2011), which may suggest a link between this band of SFs and face processing abilities.

Eye-tracking studies also provide some insight into the potential importance of the eye region of the face for predicting individual differences in face processing ability. For instance, Sekiguchi (2011) showed that participants with higher face memory abilities tend to fixate the eyes more than individuals with lower face memory abilities. However, a more recent study using a different task to measure eye movements obtained a correlation between time spent fixating the nose region and face recognition ability in control observers (Bobak, Parris, Gregory, Bennetts, & Bate, 2017). Nevertheless, the features that are fixated foveally by an observer are not necessarily *used* for a given task (Arizpe, Kravitz, Yovel, & Baker, 2012; Blais, Fiset, Roy, Saumure Régimbald, & Gosselin, 2017; Jonides, 1981; Posner, 1980). This potential link between individual differences in face processing abilities and use of facial information can be directly investigated using psychophysical methods such as Bubbles (Gosselin & Schyns, 2001).

The current study explores how variations in the ability to recognize faces in healthy observers are linked to the visual strategies used in face identification, i.e. the diagnostic facial regions and SFs for accurate face recognition. Fifty participants first completed three tasks measuring face processing abilities. A principal component analysis carried out on the results from these tests yielded a single score to assess general face processing ability (see Furl, Garrido, Dolan, Driver, & Duchaine, 2011 for a similar procedure). The participants also completed three non-face object recognition tasks to take into account the role of general recognition ability in the observers' use of facial information. Next, to pinpoint the features in which SFs are associated with face identification, we designed a 10-choice identification task using the Bubbles method (Gosselin & Schyns, 2001; see Caldara et al., 2005 for a very similar task). The general idea behind Bubbles is that by randomly sampling specific visual information on a trial-by-trial basis, we will be able to precisely determine, after many trials, what information is significantly correlated with performance in any given visual categorization task (e.g. Smith, Cottrell, Gosselin, & Schyns, 2005; Thurman & Grossman, 2008; Willenbockel, Fiset, et al., 2010; Robinson, Blais, Duncan, Forget, & Fiset, 2014; Royer et al., 2016). In this case, we combined the Bubbles results and the face identity factor scores derived from a principal component analysis to reveal which facial regions at which spatial frequency ranges are significantly correlated with face recognition accuracy.

2. Materials and method

2.1. Participants

Fifty (28 women) Caucasian, right-handed participants provided informed consent to complete several tests for this study: three face recognition tasks and three object recognition tasks completed in a counterbalanced order. Participants also completed a 10-choice identification task using Bubbles. All participants were between 18 and 40 years of age (mean age of 23.9, S.D. = 4.4). The study was approved by the Université du Québec en Outaouais's Research Ethics Committee and was conducted in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki). The number of participants was set at fifty to include individuals with a wide range of face and object recognition ability in our sample. All participants had normal vision as indicated by their score on the Snellen Chart and Pelli-Robson Contrast Sensitivity Chart (Pelli, Robson, & Wilkins, 1988).

2.2. Apparatus

The experiments were conducted on MacPro QuadCore computers. Stimuli were displayed on a 22-inch 120 Hz Samsung LCD monitor. The monitor's resolution was set to 1680×1050 pixels. Minimum and maximum luminance values were 0.4 cd/m^2 and 101.7 cd/m^2, respectively. The participants were seated in a dark room and viewing distance was maintained constant with a chinrest. Relation between luminance and RGB values was set to linear.

2.3. Face and object tasks

Each participant completed a total of six face and object recognition ability tests: the Cambridge Face Memory Test + (CFMT+; Duchaine & Nakayama, 2006; Russell, Duchaine, & Nakayama, 2009; see also Cho et al., 2015), the Cambridge Face Perception Test (CFPT; Duchaine, Germine & Nakayama, 2007), the Glasgow Face Matching Test short version (GFMT; Burton, White, & McNeil, 2010), the Horse Memory Test (HMT; Duchaine & Nakayama, 2005), the Cambridge Car Memory Test (CCMT; Dennett et al., 2012), and the Cambridge Hair Memory Test (CHMT; Garrido et al., 2009). All Cambridge tests were programmed in Java; the others (GFMT and HMT) were programmed in Matlab (Natick, MA) using functions from the Psychophysics toolbox (Brainard, 1997; Pelli, 1997).