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How does typicality influence memory: exploring the effects of shifting attention to distinctive face features on own-race bias

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Abstract

The own-race bias is a robust effect where participants show better memory for faces of their race. Hills and Lewis (2011) found that shifting attention to distinctive black face features reduces the bias for white participants. Nevertheless, social categories such as race are graded and their members can vary on their representativeness of the category (E. Rosch & Mervis, 1975). Tanaka and Corneille (2007) showed atypical faces are more easily recognised than typical faces and Kleider-Offutt et al. (2017) demonstrated that prototypicality can affect the activation of category association. Our hypothesis states that the more typical a face is, the less efficient the attentional shift is in reducing the own-race bias.

Our results replicated the own-race bias (ORB), but we could not replicate Hills and Lewis's (2011) results. We also did not confirm our hypothesis, since the only effect on typicality was a higher recognition for atypical faces of both racial groups.

Keywords: ORB; Memory; Cognitive penetration

Resumo

A memória para faces é essencial no reconhecimento de indivíduos e como tal para a vida social humana. A investigação de Sato e Yoshikawa (2013) demonstra que faces são melhor recordadas que outros estímulos visuais como por exemplo cenários, objectos ou mesmo faces invertidas. Ainda assim, a nossa memória para faces continua susceptível a erros e enviesamentos. Um desses enviasamentos é o *own-race bias* (ORB).

O ORB é um efeito robusto, presente em estudos de reconhecimento de faces, onde os participantes demonstram de forma consistente uma maior capacidade de reconhecer faces da sua raça. Apesar da consistência do efeito ainda não foi possível identificar o mecanismo responsável por estes resultados experimentais. A investigação realizada na área apresenta dois grupos de modelos teóricos: modelos de perícia perceptiva e modelos de cognição social. Os modelos de perícia perceptiva defendem que devido à segregação racial, e à consequente diminuição de contacto entre grupos raciais, os indivíduos acabam por se tornar mais competentes a diferenciar faces semelhantes às encontradas na sua experiência pessoal, o que por sua vez significa uma melhor aptidão para faces do seu grupo racial. De forma geral, estes modelos justificam as diferenças na capacidade de reconhecimento dos participantes com a diferenciação das representações mentais dos estímulos ou com a diferenciação do processamento das próprias faces. Por outro lado, os modelos de cognição social justificam o ORB através de um processamento diferente para as faces do *in-group* (mesmo grupo racial) e do *out-group* (outro grupo racial). S. G. Young et al. (2012) demonstrou que para estímulos onde os participantes tenham a mesma perícia, a criação de grupos mínimos tinha constantemente impacto na performance do reconhecimento das faces, com os participantes a reconhecer mais facilmente as pessoas do seu *in-group*. Segundo os modelos de cognição social, os participantes pensam nos membros do *out-group* enquanto representantes de uma categoria, ao contrário do que acontece para os membros do *in-group*, que são processados como indivíduos. Neste contexto, é tido como um benefício processar as faces dos estímulos experimentais considerando que são indivíduos, pois desta forma é aumentada a eficiência do reconhecimento facial. Isto acontece uma vez que o foco é direccionado para as características únicas do indivíduo. O mesmo não acontece quando a prioridade é categorizar, visto que isso implica alocar a atenção em características comuns aos membros do grupo social em causa, que muitas vezes são verificadas com a procura de mais características indicadoras do grupo social.

Neste momento, nenhum destes grupos de modelos teóricos é capaz de explicar os vários dados da literatura do ORB, sendo que já existem modelos híbridos, que procuram integrar e analisar os dados e os argumentos que corroboram os modelos de perícia perceptiva e os modelos de cognição social. Na realidade o ORB é mais complexo do que apenas um efeito de perícia perceptiva ou de pertença a um grupo social específico. Estes modelos hibridos procuram uma integração holística dos dados da literatura, de forma a encontrar uma teoria mais completa na explicação do ORB.

Neste estudo, é pretendido aprofundar o entendimento dos resultados de Hills e Lewis (2011), onde estes demonstraram reduzir o ORB em participantes brancos, através de uma cruz de fixação precedente ao estímulo facial que orienta a atenção dos participantes para as partes distintivas em faces de pessoas negras. Porém, as categorias sociais como a raça apresentam uma grande variabilidade e são graduais, sendo que os seus membros podem variar na sua representatividade da categoria (E. Rosch & Mervis,

1975). Isto significa que as características faciais diferenciadoras numa população de pessoas negras podem alterar substancialmente quando comparadas com as de outra população. Nesse sentido, é pouco claro o contexto em que se verificam as observações de Hills e Lewis (2011) uma vez que os resultados estão dependentes dos estímulos usados no seu estudo e da sua tipicidade.

Segundo Tanaka e Corneille (2007) as faces atípicas são mais facilmente reconhecidas que as faces típicas e Kleider-Offutt et al. (2017) demonstrou que a prototipicidade pode afectar a activação da associação à categoria. A nossa hipótese é que quanto mais típica for a face, menos eficiente será a orientação da atenção a reduzir o *own-race bias*, visto que as estruturas faciais onde a atenção é alocada deverão apresentar menor variabilidade em faces tipicamente africanas, uma vez que a atenção está a ser alocada em características que são diagnósticas do grupo social em causa. Na realidade, o próprio conceito de raça apresenta uma dinâmica que dificulta a definição de características que sejam úteis para individualizar os seus membros.

O método de alocação da atenção para as características faciais distintivas também levanta questões, e não é claro a forma como uma cruz de fixação pode garantir a qualidade da atenção às características que são observadas após garantir a fixação das mesmas. Na realidade, há poucas evidências de que esta forma de alocação da atenção permita ter impacto no processamento dos estímulos faciais (Raftopoulos, 2019). A investigação feita sobre o ORB aponta para a diferenciação do processamento de caras da própria raça em relação a caras de outra raça. No entanto, a influência extra perceptual do estudo de Hills e Lewis (2011) apenas afecta as primeiras partes da cara que serão visualizadas, e isso não deveria condicionar o processamento da mesma.

Wittwer et al. (2019) não conseguiram replicar os dados de Hills e Lewis (2011) no seu estudo. Neste estudo, iremos tentar replicar os resultados de Hills e Lewis (2011) controlando a tipicidade das caras estímulo. Para o fazer realizamos um primeiro estudo online, onde várias faces foram avaliadas por participantes Portugueses, que instintivamente, classificaram as mesmas consoante o quão representativas eram da categoria racial a que estavam associadas. Estes dados foram depois comparados com uma serie de medições físicas das características relevantes.

Num segundo estudo, foi replicado o trabalho de Hills e Lewis (2011), sendo que não foi possível reproduzir os seus resultados. No entanto, Encontramos de forma significativa o efeito do ORB e também uma melhor capacidade de reconhecimento para faces atípicas de ambas as raças. Contudo, não conseguimos encontrar o efeito que esperávamos na nossa hipótese, visto que os participantes não beneficiaram de ter a cruz de fixação a alocar a atenção inicial para o nariz e boca dos estímulos faciais de pessoas negras, querem fossem faces típicas ou atípicas. Apesar de não ser significativo, encontramos um benefício da cruz de fixação no nariz de estímulos faciais de pessoas brancas. Estes resultados demonstram que é necessário fazer uma investigação mais intensiva, capaz de explicar concretamente quais os contextos onde se pode reproduzir os resultados de Hills e Lewis (2011). É também discutido algumas das dificuldades de replicação de resultados experimentais, uma questão transversal a várias áreas científicas. Por fim é destacada a necessidade de integração de matérias de estudo das várias áreas da ciência cognitiva, de forma a acelerar a evolução da ciência e das questões do estudo da cognição.

Keywords: ORB; Memória; Penetração Cognitiva

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Acronyms

A' recognition sensitivity. 24, 25

B'' response criterion. 24, 25

CIM categorization-individuation model. 10, 31

COD coefficient of dispersion. 21

CR cross-race. 3–10, 18, 23, 27, 28

IOM in-group/out-group model. 10

ISI interstimulus interval. 24

OR own-race. 4, 7–9, 18, 23, 28

ORB own-race bias. iii, v, vi, 1, 3–13, 16–18, 23, 27–29, 31

QRPs questionable research practices. 29

STS superior temporal sulcus. 2

Chapter 1

Introduction

Most people are proud of their memory for faces. Nevertheless, they ignore how the racial/ethnic groups of the faces can affect their performance. When performing memory tests, participants show better results for memorising faces of their race. This phenomenon is known as ORB and despite the unanimity of the results (Hills & Lewis, 2011; Ng & Lindsay, 1994; S. G. Young et al., 2012), there is no consent explaining the phenomenon.

For a deeper understanding of the issues raised, this theoretical introduction will start with an overview of face recognition literature, followed by a detailed section on the ORB itself. The third section approaches social categories with a focus on typicality, which is highly relevant in memory tests (Light et al., 1979; Tanaka & Corneille, 2007), finishing off with a small inquiry of what is race. Whatever race might be, it is perceived and, in the fourth section, the cognitive penetration literature is explored, addressing top-down effects of social categories on cognition and feature selection, specifically on face recognition. In the last section, study details are discussed.

In the current thesis, face stimuli typicality was assessed for Portuguese participants and contemplated in a replication of Hills and Lewis's (2011) experiment, with that additional variable. Hills and Lewis (2011) researched the effects of directing the initial gazes to specific facial features on recognition accuracy, and found that lower fixation cross, directed at the mouth and nose, enhance black faces recognition. For the present experiment, it was expected that their results would only be consistently replicated among atypical black faces, since similar mouths and noses are usually indicative of typical black faces (D. S. Ma, Koltai, et al., 2018).

1.1 Face recognition

Can you imagine life without being able to recognise faces? Humans are highly social animals - we feel better when we share experiences, emotions and stories. For that, faces are very useful since they allow us to distinguish feelings and individuals. Nowadays, on social networks, faces are more frequent than ever, but face recognition is not a modern human necessity. Monkeys are very competent at face recognition, and face stimuli are of the utmost importance, carrying a wealth of social information (Tsao et al., 2008), which is vital for primates (Gauthier & Logothetis, 2000). In consonance with Darwin, throughout evolution, a high selective pressure must have been applied to the neural procedures behind face recognition (Nelson, 2001; Tsao et al., 2008).

Through a face, we can deduce age, sex, race, emotional state and even predict a behaviour (S. G.

Young et al., 2012). Face recognition is so important that we are trying to teach machines to be as efficient as we are. However, building a computer system that can match our face recognition system is still a daunting task to our current technology level (Zhao et al., 2003). Human face recognition is affected by the ambience and works with a broad spectrum of stimuli (Damasio et al., 1982; Zhao et al., 2003).

Behavioural, neuroimaging and brain lesion studies bring evidence that recognition of faces is qualitatively different from recognition of other objects (Gauthier & Logothetis, 2000). Most objects can be recognised at a categorical level, such as a car or a tree, but faces should be recognised at the exemplar level (Damasio et al., 1982; Gauthier & Logothetis, 2000).

1.1.1 Behavioural studies

Behavioural work indicates faces are better recognised than other stimuli such as upside-down faces or scenes (Sato & Yoshikawa, 2013; Yin, 1969). Yin (1969) demonstrated that face recognition was impaired by the disruption of the face features configuration. Suggesting that faces were processed as a whole unit in a holistic or configural processing (Gauthier & Logothetis, 2000; Rhodes et al., 1989; A. W. Young & Burton, 2018). Nevertheless, some behavioural work points that other objects, from a homogeneous category, can be processed like faces when subjects have enough expertise discriminating between exemplars of that category (Diamond & Carey, 1986; Gauthier & Logothetis, 2000).

Homogeneous categories share features and first-order configuration of their parts (Diamond & Carey, 1986; Rhodes & McLean, 1990) so they can only be distinguished using subtle differences in the dimensions of their features or in the configuration of their parts, which for faces are the distances between face features (Gauthier & Logothetis, 2000). The importance of experience in face recognition is clear (A. W. Young & Burton, 2018) and Pascalis et al. (2002) demonstrated that it modulates the expertise of infants, through a perceptual narrowing phenomenon (Pascalis et al., 2002).

1.1.2 Neuroimaging

Work in neuroimaging has established the existence of a cortical area in the right fusiform gyrus which is important for face recognition (Kanwisher et al., 1997; Sergent et al., 1992). The same area can be activated for discrimination between homogeneous categories (Gauthier & Logothetis, 2000; Gauthier et al., 2000). However, cortical responses to faces in humans implicates several regions such as areas of the occipital, temporal and frontal lobes (Gauthier & Logothetis, 2000). Studying primates Perrett et al. (1992) hinted that several sub-areas of the temporal cortex were responsive to faces, including the superior temporal sulcus (STS), and Puce et al. (1998) found an area of the human STS that was activated by eyes and mouth movements.

Primates reveal several different neocortical and limbic structures that respond preferentially to face stimuli and changing configural order of the face features diminishes the response (Gauthier & Logothetis, 2000). Nevertheless, these results don't explore if the activation is highly selective for faces (Gauthier & Logothetis, 2000).

1.1.3 Familiar and unfamiliar faces

The neural procedures behind face recognition evolved in the ambience of relatively small social groups (Layton et al., 2012), and the recognition of familiar faces is fundamental for retrieving specific knowledge and maintain interactions (Bruce & Young, 2012; Bruce & Young, 1986). These are the faces we individuate with the most proficiency, even if we have to deal with variability in the stimuli (Bruce, 1994; Longmore et al., 2008). However, our expertise seems to be less efficient for unfamiliar faces (Ritchie et al., 2015; A. W. Young & Burton, 2018).

Enhancing face expertise for unfamiliar faces is hard, and most training attempts fail (Towler et al., 2014; White et al., 2014; A. W. Young & Burton, 2018). The quality of the contact with the unfamiliar faces can improve recognition (Tanaka & Pierce, 2009; Walker et al., 2007; S. G. Young et al., 2012) but the quantity of contact is poorly relevant (Ng & Lindsay, 1994; White et al., 2014). Nonetheless, inferences concerning social categories such as race, gender and age are still highly accurate (Bruce & Young, 2012; Todorov, 2017), allowing the categorisation of unfamiliar faces to be fast and precise (A. W. Young & Burton, 2018). A. W. Young and Burton (2018) proposed that these abilities in social categorisation represent a simple process behind a more complex pattern of expertise for recognition of familiar faces.

1.1.4 Biases

Humans are very efficient and intuitive in the detection and analysis of facial information. Nevertheless, our intuitive processes can sometimes lead us to mistakes or biases (Ritchie et al., 2015; A. W. Young & Burton, 2017). The ORB is a clear example (A. W. Young & Burton, 2018), and such bias may have an impact on real-world interactions, for instance, in passport control and witness testimony (Davies, 1996; White et al., 2014). An eyewitness can be mistaken even when they are certain that they are correct (Davies, 1996) and they have a significant impact on suspects identification and consequently on the outcome of a trial (S. G. Young et al., 2012).

1.2 Own-race bias

Several studies consistently showed that participants had a better memory for faces of their race in recognition tests (Adams et al., 2010; Goldinger et al., 2009; Herzmann et al., 2017; Hills & Lewis, 2011; Meissner et al., 2005; Ng & Lindsay, 1994; Shepherd & Deregowski, 1981; Wright et al., 2003; S. G. Young et al., 2012). This effect is known as ORB, it is a statistically robust bias and is expandable to different ethnic groups. Even so, there is not an isolated mechanism responsible for the ORB (Correll et al., 2017; Shepherd & Deregowski, 1981; S. G. Young et al., 2012). Cross-race (CR) face recognition is usually stained by a specific type of error - false alarms. This means that CR faces are more frequently considered previously seen even when they have never been shown to the participants (Meissner & Brigham, 2001). Theoretical models that explore the ORB fall into two major groups: perceptual expertise models or social cognition models.

1.2.1 Perceptual expertise models

Racial segregation can result in less contact between racial groups and many theoretical explanations for the ORB claim that the systems of face perception may be tuned by individual experience (Correll et al., 2017) which leads perceivers to develop greater expertise processing and distinguishing between faces belonging to members of their race, relative to those of other races. However, the specific processes that develop with experience are still to be clarified (Michel et al., 2006). Commonly perceptual expertise models rely either on differential mental representations or differential processing of own-race (OR) and cross-race (CR) faces (S. G. Young et al., 2012).

Differential processing mechanisms

The models that rely on differential processing mechanisms claim that greater expertise with OR faces endorse holistic processing, while lesser expertise with CR faces results in featural processing (Diamond & Carey, 1986; Michel et al., 2006; Rhodes et al., 1989; S. G. Young et al., 2012).

Holistic processing is characterised by extracting the relationship between facial features, which allows the face to be processed as a unified object (Maurer et al., 2002). This transcribes into enhanced recognition because there is an increase of speed and efficiency in the extraction of spatial relationships for a stored holistic facial representation (Maurer et al., 2002) when compared with the extraction of a stored featural facial representation (Rhodes et al., 1989; S. G. Young et al., 2012).

Yin (1969) demonstrated that disrupting the facial features configuration diminished face recognition and Rhodes et al. (1989) hypothesised that if CR faces are processed with a featural mechanism, then the impairment of the upside-down faces from Yin (1969) experiment should affect more the recognition of OR faces. As predicted OR recognition dropped to that of CR, with little impact on CR recognition (Rhodes et al., 1989).

Experts seem to use holistic processing more frequently to discriminate between stimuli of homogeneous categories (Diamond & Carey, 1986). Different paradigms can evaluate the holistic processing of faces by disrupting the face features configuration (S. G. Young et al., 2012). A commonly used paradigm is the composite face, where the top half of a face is aligned with a different face bottom half. This creates a new facial configuration (Murphy et al., 2017). When subjects have to recognise the upper half of a composite-face, OR recognition was more impaired by the different bottom half, which demonstrates that OR faces are processed more holistically (Michel et al., 2006). Such results suggest that race can cause an impairment of holistic face processing.

These differential processing mechanisms for different races are presumably caused by a deficit in the perceptual experience of CR faces (Chiroro & Valentine, 1995; Diamond & Carey, 1986; Rhodes et al., 1989), which is important for our ability to recognise them (Brigham, 1986; Chiroro & Valentine, 1995). Self-reported contact with the CR population is a reliable predictor of the ORB (Rhodes, Ewing, et al., 2009) and controlled laboratory training programs can enhance CR recognition (Elliott et al., 1973; Tanaka & Pierce, 2009). It is relevant to ask whether different cues are extracted from OR and CR but the differences in recognition appear to be mainly caused by a weaker ability to extract spatial relationships (Freire et al., 2000; Rhodes et al., 1989).

Representational models

Valentine (1991) proposed that the ORB was the result of distinct frequencies of memory representations for faces of different races. This alternative perspective claims that memory has a face-space of N dimensions. In this face-space model, the N dimensions are the face's characteristics, and each face has its coordinates (see Figure 1.1). According to this model, the centre of the space would be the average face for each individual, and greater expertise with a certain race would represent a more dispersed distribution of the faces throughout the dimensions that are distinctive for that group (S. G. Young et al., 2012). In the ORB, lesser expertise would impair the dispersion of distinctive dimensions for CR faces, producing a clustered distribution on the face-space, with the CR faces stashed together in the periphery (S. G. Young et al., 2012). According to the Representational models, this could result in less selective activation of memory, triggering multiple exemplars when exposed to within-category stimuli (Byatt & Rhodes, 2004). This theoretical framework is consistent with the increase of false alarms that characterise the ORB (S. G. Young et al., 2012).

Representational models are compatible with the experiments that report an enhancement for recognition in subjects with higher interracial contact (Elliott et al., 1973; Rhodes, Ewing, et al., 2009). Basically, experience with more faces translates into higher dispersion of the representations in the face-space dimensions. In an important paper for the current thesis, Hills and Lewis (2011) trained individuals in specific distinctive dimensions to extenuate the ORB. The rationale underlying their work was that if a specific facial dimension is distinctive for CR faces, then training or allocating attention to that dimension should improve recognition. They tested this hypothesis with an experiment where a fixation cross allocated the first gazes to different face regions, namely the mouth, which had been identified as a feature used by black participants to describe black faces (see Ellis et al., 1975). They hypothesise that if the lower regions of the face are more used for individuation among Black faces, then focusing on those distinctive dimensions should increase recognition. Their results confirmed the hypothesis, and the ORB was reduced for black faces when the fixation cross was situated lower in the face, indicating that allocating attention to those features improved recognition for black faces.

Research exploring the distinctiveness effects presented evidence that interracial contact increases the distribution of CR faces in the face-space (S. G. Young et al., 2012). These effects point out to the propensity of atypical faces to be better remembered but less easily categorised (Wenger & Townsend, 2005), which is coherent with representational models face-space in memory. Since most faces contain more prototypical features than highly unique features, the density of faces will be higher near the centre of the face-space, where the most prototypical face should be. As a result, a cluster of nearby faces would be triggered by a highly typical face, inducing category association but impairing recognition by increasing false alarms (Levin, 1996, 2000). Contrarily, atypical faces are allocated farther from the more populated regions of the face-space, activating fewer exemplars and facilitating individuation and recognition but demanding more efforts to categorise (Valentine & Endo, 1992).

Objections for Perceptual Expertise Models

All perceptual expertise models concur that experience with CR faces increases recognition. Nonetheless, the assumed relationship between contact and recognition accuracy is not clear (Malpass & Kravitz, 1969; Ng & Lindsay, 1994; Palma & Garcia-Marques, 2020; S. G. Young et al., 2012). The amount of visual experience with CR faces is undoubtedly an important factor in the ability to recognise them, al-

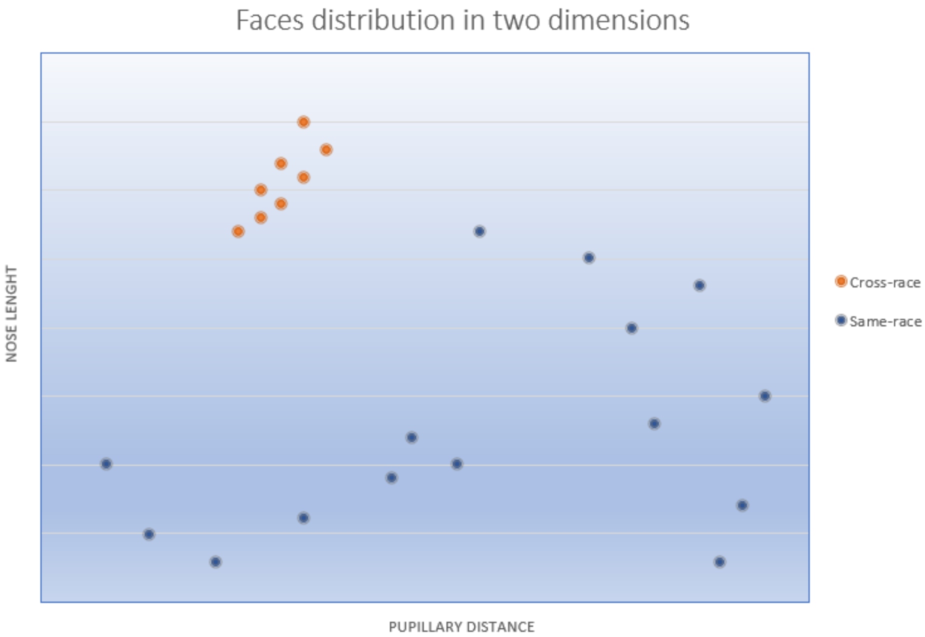

Figure 1.1: Representation of face-space for two dimensions and the distribution of same race and cross race e those dimensions. Adapted from Young, S. G., Hugenberg, K., Bernstein, M. J., & Sacco, D. F. (2012). Perception and motivation in face recognition: A critical review of theories of the cross-race effect [PMID: 21878608]. *Personality and Social Psychology Review*, *16*(2), 116–142. https://doi.org/10.1177/1088868311418987

though it appears to be the quality of CR contact, rather than the quantity, that is critical (Brigham, 1986; Chiroro & Valentine, 1995). Palma and Garcia-Marques (2020) showed that repetition could not reduce the ORB, despite its influence on learning and memory. Meissner and Brigham (2001) found that only 2% of the variance in the ORB was caused by distinct contact with CR groups, a small but statistically significant effect. It appears that contact is relevant when it requires attentive and effortful encoding of CR faces (Walker & Hewstone, 2006). Tanaka and Pierce (2009) demonstrated that individuating faces while training (e.g., that face is Bob) increased recognition while categorising left the ORB intact, even with the same time to study CR faces.

Indeed, the ORB can be impaired when individuals are trained to discern between CR faces (Elliott et al., 1973; Wenger & Townsend, 2005), and their performance can be improved by directing attention to distinctive features on which CR faces can be individuated (Hills & Lewis, 2011). These effects appear shortly after starting training (Elliott et al., 1973), but also vanish quickly (Meissner & Brigham, 2001) and, conjointly, these time constraints are inconsistent with how expertise is usually developed (Ericsson et al., 1993).

Differential processing mechanisms have their objections since Yin (1969) inversion paradigm has obtained mixed findings and, despite Rhodes et al. (1989) results, some studies have not found evidence of featural processing for CR faces with the inversion paradigm (Valentine & Bruce, 1986).

Valentine (1991) face-space has been effective clarifying some effects of race on face recognition, but has also been questioned for not pointing out the specific dimensions that are responsible for storing the faces in this face-space (Levin, 1996).

1.2.2 Social Cognition models

According to the research in social cognition, the ORB is the result of distinct processing for the in-group faces and the out-group faces. S. G. Young et al. (2012) demonstrated that for the same perceptual expertise, minimal groups consistently produced changes in recognition performance, with participants showing better memory for the in-group faces. Research indicates a bias. Participants think categorically about out-group members while using more individuated processes for in-group members (S. G. Young et al., 2012). The tendency to perceive out-group members as more homogeneous is an established effect, known as the out-group homogeneity effect (Judd, 1988). Following these theories, the individuated processing, used with in-group faces, leads to a more efficient recognition. Meanwhile, the out-group faces are categorised, leading to inferior memory performance. Individuation depends on the unique characteristics of a target, while categorisation implicates a social group membership, such as race, sex, age. Perceivers treat own-race faces more as legitimate faces and as individuals, but allocate more attention to other-race faces and categorise them quicker (D. S. Ma, Correll, et al., 2018).

Social cognitive models for the ORB elaborate these theories towards the perceptual domain of recognition biases (Hugenberg, Young, et al., 2010; S. G. Young et al., 2012), and from their perspective the ORB is a perceptual expression of rooted categorisation and individuation processes common in social cognition. Despite undermining the value of race for the differences in recognition, a few social cognitive theories have been presented to explain the ORB.

The feature-selection model

Levin (1996, 2000) defends that the ORB is caused by thinking categorically about out-group members. While a perceiver thinks categorically about out-group members, he will look to category-specific features, impairing the encoding of identity specific features in CR faces. Considering that in-group faces need to be processed in an individuated way, perceivers look for identity specific features, which would allow them to distinguish in-group members. This indicates that perceivers are motivated to observe facial features in different ways for OR and CR faces. According to Levin (1996, 2000), encoding only the race specifying features of CR faces results in a hurdle for face recognition, which explains the ORB.

The central argument in this model suggests that OR and CR faces are treated differently — with two different search processes used to scan facial features. Some of these facial features identify race and an observer from another race will probably notice them faster, making CR faces feature-positive targets. For Levin (1996), this culminates in observers recognising OR faces better while categorising CR faces faster.

While testing the feature-selection model with African and Caucasian faces, Caucasian observers could find an African face among Caucasian faces faster than a Caucasian face among African faces (Levin, 1996, 2000). The differences in complexion result in dark skin being a feature-positive. This kind of information is bound to the ORB, since it facilitates detection but complicates recognition. The feature-selection model is also supported by results where faster search times and faster reaction times in categorisation for CR faces anticipated slower and less precise recognition (Ge et al., 2009; Levin, 1996, 2000). Categorisation and individuation appear to be mutually exclusive processes during face encoding.

Cognitive disregard

Cognitive disregard is a different social cognition model that uses motivation to explain the effects of the ORB (Rodin, 1987).

This model conjectures that an observer will hesitate before allocating resources to individuate a face that is not certain to be relevant. Indeed, some social situations demand only social category information to resolve the interaction. Rodin (1987) suggests that in such situations where the identity of the target is irrelevant, they can be perceptually disregarded.

Cloutier et al. (2005) found evidence that social categories are extracted faster and with less effort than facial identity, and some social agents are processed just until they are associated with a social category (Wegner & Bargh, 1998). This is congruent with the cognitive disregard model which predicts that category information might indicate relevance, conditioning face encoding and recognition.

Any social category can induce disregard and Rodin (1987) assumed that age could act as race in face recognition. The premise of Rodin (1987) was that for many college-age individuals, middle-aged targets are less socially relevant and vice versa. He found an own-age bias in both college-age and middle-aged subjects. By these results, the ORB was the consequence of automatic categorisation for CR faces (Levin, 1996, 2000), while the race category serving as a cue to disregard these individuals.

Eye-tracking research reveals that CR faces are less gazed at and over fewer face regions (Goldinger et al., 2009). Participants also detach their attention from CR faces faster than OR faces, meaning that more study time only increased the gap between recognition of CR and OR faces (Goldinger et al., 2009). This study from Goldinger et al. (2009) also establishes an association between poor performance for face recognition with gaze behaviour and pupil dilations, which is an indicator of mental effort.

Research in Social Cognition exposes recognition biases for several social out-groups. In fact, even minimal groups can elicit a bias, such as a college membership or personality type (Bernstein et al., 2007). The effects are also replicable to other nonracial social categorisations, like socioeconomic status (Shriver et al., 2008), cross-sex (Cross et al., 1971), cross-sexualorientation (Rule et al., 2007) and cross-religious affiliation (Rule et al., 2010). For Rodin (1987), all these examples share a disregard for an out-group target and the perceiver is not sufficiently motivated to encode the out-group faces.

Objections for Social Cognition models

Some research data is hard to justify within the scope of Social Cognition models. Experiments where training enhances CR face recognition (Elliott et al., 1973; Tanaka & Pierce, 2009), are difficult to interpret. Rhodes, Locke, et al. (2009) tried to decrease CR recognition encouraging race categorisation, but this manipulation had no effect on face recognition. Although interracial stimuli composition can justify these results, since watching a racial out-group face can trigger racial categories (Dixon & Maddox, 2005), which without further manipulation lessen face recognition (S. G. Young et al., 2009). Levin (1996) found that Black participants were faster to categorise Black faces, which was incoherent with his own theory.

Beyond these results, if the ORB is the result of in-group/out-group differentiation, then it should develop simultaneously with other biases. Granting all this is hard to test, the biases on more generic dimensions seem to emerge later in childhood while the ORB arises early (Baron & Banaji, 2006; McKone et al., 2009).

Rodin (1987) cognitive disregard model is too generic and has no way to explain the high rates of false alarms in the ORB (Meissner & Brigham, 2001) since disregard should result in random guessing. Anderson et al. (2010) established that regard could enhance attention but the attention and relevance together did not improve recognition. Furthermore, even though Goldinger et al. (2009) found variations in the allocation of attention for CR and OR faces, diverse studies found increased attention allocation for CR faces (Richeson & Trawalter, 2008).

1.2.3 Hybrid models

None of the theories described so far can alone explain all the outcomes in ORB literature. Research exploring the relationship between contact and the ORB has yielded mixed results. Increased time of contact shows less relevance than the quality of that time for heightening expertise and increased expertise does not cause the holistic processing of faces (S. G. Young et al., 2012). Certainly, social categories such as race, sex, age or others, that can divide targets into in-group or out-group, have an influence on perceptual face encoding (Freeman et al., 2010; Ito & Urland, 2003) and the subsequent processing (Hugenberg & Corneille, 2009; Jones, 2009; Tulving, 1985). But social cognitive models are inadequate to explain all the results in recognition bias literature.

Taken together, the ORB requires attention to factors beyond categorisation or increasing the expertise. Social and expertise variables can act together to affect the ORB. But only a few hybrid models sought to combine perceptual expertise and social cognition models (Correll et al., 2017; S. G. Young et al., 2012). These hybrid models are distinct and they don't just supplement one theory with another. They change the focus from one against the other to open the way for integration and communication in search of a more complete theory. Here we review three hybrid models that use different core mechanisms with their ups and downs, waiting for more data to be challenged and further tested.

Dual-process model

The dual-process model is influenced by Tulving's (1985) multiple memory systems. This model considers that face recognition is achieved by two memory processes with different resource allocation - familiarity and recollection (Jones, 2009). This results in some faces appearing familiar while others being recollected. Influenced by Rodin (1987), the social importance of the stimuli for the participant is what establishes the memory process (Meissner et al., 2005). As reviewed by Yonelinas (2002), familiarity processes consistently increased false alarms which would be compatible with the kind of errors done in CR recognition (Meissner & Brigham, 2001).

Researchers use the Remember-Know-Guess paradigm (Tulving, 1983) to deduce what memory process was selected to answer a recognition test. Studies that use this paradigm add another layer to the recognition test, where the participants report what kind of phenomenological experience motivated a recognition of a stimulus as previously studied. In short, participants have three options: Remember when they have specific memories to motivate the recognition; Know if the stimulus is familiar but they can't fetch specific phenomenological information; Guess if they have no clue on what made them answer that way (Gardiner et al., 2002). Meissner et al. (2005) implemented this paradigm to the ORB and found that recognition of OR faces relies on recollection memory processes.

The dual-process model also takes into account expertise. Contact with CR can change the way faces are coded, and higher expertise will affect the competence in recollecting the facial features necessary to individuation, which will sustain the high demand recollection processes (Hancock & Rhodes, 2008).

In-group/out-group model

According to the in-group/out-group model (IOM), early in face perception, the perceiver verifies if the stimuli is a member of an out-group or an in-group (Sporer, 2001). What happens after that is dependent on the categorisation of the target, but the logic is similar to other models. In-group faces are processed in a complex configural manner, while out-group categorisation induces less efficient recognition processes typical of low expertise (Tanaka & Farah, 1993).

The IOM combines the strengths of the social cognition models and the mechanisms behind the perceptual expertise models, suggesting that any inter-group discrimination should develop into different encoding processes (Sporer, 2001). These statements are supported by Goldstone and Queller's (2006) study, where racially ambiguous faces are processed differently when labelled as in-group members or out-group members. Beyond that, minimal groups, such as college or political party affiliation, can induce different processing even without expertise differences (Hugenberg & Corneille, 2009).

Categorisation-individuation model

Hugenberg, Young, et al. (2010) developed a theoretical framework that could address the weaknesses of the other models. At the core of the categorization-individuation model (CIM) is the presupposition that faces can be encoded in a categorisation or individuation way.

He argued that the ORB was the result of the convergence of social categorisation, motivated individuation and perceptual experience. The CIM claims that the three factors play a role in different interdependent processes that modulate face recognition. Social categorisation can lead to difficulties in the differentiation of faces when a strong category activation is present. The motivation to individuate the targets is decisive in the efficiency of the recognition, while expertise facilitates face memory.

This hybrid model claims that there is a bias to unconsciously extract category-specific information from faces (Cloutier et al., 2005; Ito & Urland, 2003; Levin, 2000). The focus of attention in similar features that are indicative of the category leads to homogenisation of the representations in memory. The CIM also anticipates that motivation can direct attention to individuating facial features, which would improve recognition accuracy. Since the identity-distinctive features are harder to extract than category indicative features, even perceivers with high expertise need some motivation to individuate a target face. The last prediction of the CIM is that expertise with a category of faces will ease the extraction of identity distinctive facial features.

Low-level perceptual characteristics used to differentiate among social categories are swiftly extracted and precede the extraction of more precise individuating information (Cloutier et al., 2005; Hugenberg & Sacco, 2008; Ito & Urland, 2003). Nevertheless, the influence of categorisation affects face memory through motivation. This prediction of the CIM is consonant with Rodin's (1987) theory, where social categories serve as cues to infer the target relevance. Hugenberg, Young, et al. (2010) also note that expertise simplifies the individuation of CR faces, which would decrease the ORB (Tanaka & Pierce, 2009), even if dependent on motivation.

1.3 Social categories

Humans can be extensively categorised. Someone meeting with me for the first time will notice that I am an adult male. If we get to talk for a while, that person might even categorise me as a Portuguese student that likes pineapple in his pizza. Nonetheless, the utility and extraction of each category are different (Bodenhausen et al., 2012). Inferences about social categories are fast and precise, even for unfamiliar faces (A. W. Young & Burton, 2018).

Social groups can alter our perceptions of other human beings (Bodenhausen et al., 2012). Psychologists have devoted substantial efforts in exploring the mechanics behind social categorisation and the consequences on downstream social cognition (Bodenhausen et al., 2012; Maner et al., 2012). Social categorisation influences our impressions of others and the way we respond to their behaviour (Dunning & Sherman, 1997). Memory is also affected, and categories seem to play an important role in face recognition (Hugenberg & Sacco, 2008; Hugenberg, Young, et al., 2010).

The early categorisation of race can interfere with the capacity to individuate a face (Levin, 2000; Michel et al., 2006). According to Levin (1996), participants think categorically about out-group members. Ito and Urland (2003) demonstrated that within 100 ms of a face stimulus presentation, participants were aware of stimulus race, which seems to be encoded automatically.

By what mechanism the brain allows automatic categorisation of individuals to their racial group remains unclear (Zhou et al., 2020) but the process appears to be relevant for the ORB (Hugenberg, Young, et al., 2010). Zhou et al. (2020) kept track of the processing of low-level perceptual features that differ between racial groups. After isolating time courses and neural structures for the categorisation of faces from other races, they propose that distinct neural mechanisms evolve in the brain, even for other categories inside race (Zhou et al., 2020).

1.3.1 Cognitive representations of social groups

Human cognition relies on categorisation. It allows organisation and structure to our knowledge about our surroundings (Bodenhausen et al., 2012). Categories bind together entities that have some shared properties. We use them since it allows us to address an infinite number of individuals as a class (Bodenhausen et al., 2012; Sloutsky, 2003; Smith & Medin, 1981). Research suggests that our ability to categorise comes early, and even infants are able to use perceptual groupings (Benson, 2011). Nevertheless, the maturation processes and the structure behind categories persist for debate (Goldstone, 1994; D. S. Ma, Correll, et al., 2018; Sloutsky, 2003).

In cognitive science, it is broadly recognised that concepts are the mental representations that are used to determine categories (Carey, 2009; Medin & Rips, 2005). According to Bruner (1957), they are recipes for organising stimuli into categories. The classical view of concepts argued that each concept has an array of essential features (Haslam et al., 2000). Briefly, this view argues that a concept is established by a set of features that are individually necessary and jointly sufficient (Bodenhausen et al., 2012; Margolis, Laurence, et al., 1999). This definition would be adequate if we think of a concept such as triangle, but it also had several restrains. The typicality effects (E. Rosch & Mervis, 1975; E. H. Rosch, 1973b) are a strong argument against the classical view of concepts. These effects were noticed when psychologists inquired if all the members of a concept would stand as equals in their association to that concept. E. H. Rosch (1973b) demonstrated that participants could easily estimate how representative a real world entity was for a certain category. To a certain degree, even two real world triangles can be different on how representative they are of the concept triangle. Besides the robust participant ranking, more typical elements were also categorised faster. This data was brought to the philosophical debate and impacted the first real alternatives to the classical theory.

The probabilistic view claim that concepts are represented by an abstract prototype and the category membership is driven by similarity to that prototype (E. Rosch & Mervis, 1975). The exemplar view denied a singular prototype and argued that the concept was defined by the features of obvious exemplars (Medin & Schaffer, 1978). Within the context of this view, category membership is defined by similarity to other representative members of the category (Bodenhausen et al., 2012; Goldstone, 1994). Despite their differences, both these views consider that concepts and categories are established by similarity and provided the ground for many models in cognitive psychology (Goldstone, 1994). But they also face challenges when we consider concepts without a prototype (e.g. love). Notwithstanding the limits of similarity to explain membership for some categories (Goldstone, 1994), it seems to be very useful for the study of natural categories (Goldstone, 1994; E. H. Rosch, 1973a).

In this study we will not elaborate more on the theory of concepts (see Margolis, Laurence, et al., 1999; Medin & Rips, 2005, for a detailed review) since our concern is related with how people judge the category entities when they see them "out there". Sloutsky (2003) presents a thesis where multiple correlations in the stimuli form structures. These correlations are extracted by perceptual and attentional mechanisms that can detect regularities. According to this view, an entity is categorised if it shares enough similarity to a representative structure of the category (Goldstone, 1994). Category membership is defined according to our perception abilities and conditioned by the way we interact with the physical and social environment (Margolis, Laurence, et al., 1999). Members of a category can share different similarity with the representative structure, but these differences are determined by people's judgments (Margolis, Laurence, et al., 1999).

1.3.2 Typical or atypical: influences on cognition

Typicality has been interpreted as the discrepancy of similarity between category members to the representative structure of that category (Santi et al., 2016). In short, a typical category member will have more features shared with other category members and fewer features shared with members of other categories (E. Rosch & Mervis, 1975; Santi et al., 2016). Santi et al. (2016) propose that typicality is a crucial dimension to the organisation of categories.

Categories are graded and their members can vary in the degree they fit the category (Armstrong et al., 1983; D. S. Ma, Correll, et al., 2018; Palma et al., 2018; E. Rosch & Mervis, 1975). This has been a central topic of research in cognitive psychology and is true for non-social, social and face categories (D. S. Ma, Correll, et al., 2018; E. Rosch & Mervis, 1975).

Category verification tasks show that typical items are categorised faster (Kiran et al., 2007; E. Rosch & Mervis, 1975) and the category judgement of atypical items requires more effort (Santi et al., 2016). In the face recognition literature, atypical faces are more easily learned and better recognised than typical faces (Light et al., 1979; Tanaka & Corneille, 2007). These results can be interpreted by the face-space model, as typical faces will have their coordinates in a higher density face region (Tanaka & Corneille, 2007).

Nevertheless, ORB research rarely takes into account how representative the faces are of the race/category that they are supposed to fit.

1.3.3 What is race?

Working on the ORB requires a deep understanding of what is race. The easy answer is listing visible traits and identify geography and ancestry (Glasgow et al., 2019), looking for the essence of race. But even those can be different in different places of the world. If we present a filipino face, a chinese face and a mongol face to an audience from the United States, most people will identify them as asian. But an audience from China may have other racial classification for the same three faces.

So race is dependent on some variables, making it flexible. Race can be defined in different ways for different authors (Glasgow et al., 2019). The range goes from race as a biological reality to race as a non-existing thing. Either way, the social, political and cultural impact of racial segregation is evident (Glasgow et al., 2019, for further details). In our understanding, to study race in a population we should have that population classify the stimuli for category membership.

1.4 Cognitive Penetration

Human cognition has been conventionally isolated from human perception (Stokes, 2013). Yet, perception can be influenced by our beliefs, desires, expectations or intentions (Adams & Kveraga, 2015; Jenkin & Siegel, 2015; Lupyan, 2015). As stated in Siegel's (2019) work, cognitive penetration takes place when it is nomologically possible for the same visual experience to have a different content, resulting from differences in the cognitive states of the subjects. According to this approach, cognitive penetration requires the perceptual processing itself to be affected by cognition, but over forty years of research resulted in other definitions that consider different details (Raftopoulos, 2019). Nevertheless, discussing such definitions goes beyond the scope of this thesis.

It all started with Fodor (1983) comparing the human mind with computation machines and using several linguistic examples to propose that our input system is informationally encapsulated. The thesis was that the mind assimilates information through specific systems, which he calls modules. These are immune to top-down influences and are not penetrable because they only process information for the representations in the input systems computations. For instance, face stimuli would require the visual module, or several modules within vision, which would take physical inputs from the world. He argues that these modules are optimised for speed and simple computations in expectation to deliver the information for the central systems. These unspecific psychological central systems treat the received information from perception inputs, and top-down information flow happens within these systems (Fodor, 1983). Fodor (1983) proposal is hard to refute, but even he admits the existence of top-down influences.

1.4.1 Top-down influences

Lupyan (2015) argument is diametrical to Fodor (1983). He believes that all perceptual inputs are ambiguous, and that perception demands prior knowledge to guide perceptual information in a way that improves the fitness of the organism (Lupyan, 2015). For him, the purpose of the perceptual system is to grant organisms the capacity to respond to relevant stimuli (Lupyan, 2015). The argument is that perception is always influenced by cognition and that every information stored in mind can be used if pertinent for a specific task (Lupyan, 2015).

Siegel (2010) gives an example of how the basic features of a rope can cause an ophidiophobic person to see a snake, which might result in a physical response. Even an absent object can be perceived, which Farennikova (2015) argues is an example of the influence on perception from expectations. When you expect an object to be in a certain place, the visual search mechanisms will use templates from the past, which indicates that background thoughts can influence visual processing (Farennikova, 2015).

Top-down influences on perception can enhance the extraction of relevant information. Familiarity and expertise can lead cognition to evidence patterns that allow faster recognition and guide feature selection in the stimuli (Lyons, 2011; Raftopoulos, 2019).

1.4.2 Early vision vs Late vision

Raftopoulos (2019) emphasise the importance of considering perception in two stages, early vision and late vision, which are differently influenced by cognition. Early vision is responsible for fetching the information from the world, which is used to set the visual scene (Raftopoulos, 2019). It represents the initials stages of visual processing while constructing low-level properties of the stimuli, such as shape, location, motion and colour (Pylyshyn, 1999). This stage lasts for 150 ms, and signals are transmitted bottom-up (Raftopoulos, 2019). On certain occasions, categorisation and recognition can occur very fast through purely perceptual processes on early vision, thanks to stored associations of low-level properties of objects (Raftopoulos, 2019). For example, in the case of the rope/snake, the long, coiled shape caused confusion (Siegel, 2010), and it is possible that facial features can be used to quickly fit a person into a social category during early vision (Adams & Kveraga, 2015).

Late vision starts around 150-200 ms after stimulus presentation when signals from higher executive centres modulate perceptual processing (Raftopoulos, 2019). It is in this stage that we consider the objects' distinctive features which allow categorisation and recognition (Raftopoulos, 2019). This perceptual stage involves both bottom-up and top-down processing (Raftopoulos, 2019). But influences in late vision are inadequate to provide evidence for what researchers consider real cognitive penetration of perception.

Details such as time and the source of the influence are fundamental to determine the challenges for the philosophy of the mind and normative theories, including ethics, epistemology and aesthetics (Jenkin & Siegel, 2015).

1.4.3 Epistemology

Perceptual experience is usually used to justify our beliefs. After all, perceiving something provides rational support to believe what is perceived (Raftopoulos, 2019). Yet, defeasible reasoning can take place while revealing the external world through perception (Chisholm, 1957). If we look briefly at the flowers around us, we will perceive them still and that might result in a belief that flowers do not move. However, one day we might come across sunflowers and perceive them moving towards the sun. This second experience might impact our initial belief about the movement of flowers. The transparency that we attribute to our perceptual experience presumes that when we observe a phenomenon it presents the perceiver the circumstances of the environment (Raftopoulos, 2019). The phenomenal content of watching sunflowers projects that they move towards the sun and perceivers might develop a belief in accordance. In line with the phenomenal dogmatism view, when a perceiver percepts p, then the perceiver has prima facie justification for the proposition p (Raftopoulos, 2019).

But top-down influences can have an impact on the justificatory role of the perceptual experience. These influences can alter the calibration of perception to the information available in the environment, which could result in cognition selecting the input for perception (Siegel, 2013). Nevertheless, during late vision cognition can influence perception directly (Raftopoulos, 2019). After all, we use what we know to make sense of the sensorial information.

Siegel (2013) proposes that subconscious processes of the mind generate perceptual experiences. These subconscious pre-experiential states would determine the low-level perceptual information attended to build the percept but not the processing of low-level perceptual information. By itself, this scenario does not represent any epistemic fault for the perceptual experiences. To address the possibility of a reduced epistemic value of perceptual experience, Vance (2015) describes a Bayesian framework that focuses on the regulation of perceptual experiences by background beliefs. He argues that there is no evidence of impairment of the justificatory role of perception.

1.4.4 Visual attention

The allocation of attention can play a role in a subject perceptual experience. The perceptual computations of visual stimuli can influence attention with perception mechanisms (Jenkin & Siegel, 2015). Yet, exterior conditions can also influence attention allocation. One clear example of this external influence is through the spatial distribution of attention. Our focus helps us establish what will be the sources of our perceptual experience. Attending different places in a visual experience can change the outcome profoundly, as any illusionist would confirm. These differences can be related to objects, regions, features, or even low-level components of the stimuli, such as colour, shape or size (A. Treisman, 1977; A. M. Treisman & Gelade, 1980). For example, if you watch a face and focus on his colour you might fail to attend other important information for recognition tasks.

Jenkin and Siegel (2015) divide these extra-perceptual influences and lists the mechanisms and stages where influence can take place (Table 1.1). The stage where the influence takes effect can impact how we notice it on perception.

Table 1.1: List of mechanisms and states for influencing the allocation of attention.

Mechanisms
Focus - direction of gaze
Object-based attention/Spatial attention - Attended region in the stimulus
Feature-based attention - Attended features in the stimulus
Other influences in mechanisms not related with focus or attention

Stages
Early Vision
Pre-conscious percetual states
Conscious perceptual experience during late vision

Cognitive penetration requires subjects' cognition to alter perceptual processing and not merely the input to be perceptually processed. Influences on focus imply a distinct first input. Only this should not be considered a case of cognitive penetration (Raftopoulos, 2019), but selecting features in late vision might change perceptual processing (Raftopoulos, 2019). Cognitive penetration happens when a social category is inferred, and the feature-based attention mechanisms search for other indicative features to confirm the category (Raftopoulos, 2019) since the allocation of attention altered during the processing of the face.

Hills and Lewis (2011) suggested that the ORB was caused by how we allocate attention. The claim was that different races had different distinctive features, but subjects used mechanisms for feature-based attention that were more fit for their own race. Using focus, with a fixation cross, he tried to direct attention to the distinctive features of black faces and found an improvement in white participants recognition for black faces. Nevertheless, there is no evidence that the mechanisms for feature-based attention would be controlled by the initial focus. For Siegel (2013) a selection effect doesn't influence how things look to you since it lacks control during late vision. This kind of extra-perceptual influence and other possible dynamics with the allocation of attention is relevant for the face recognition literature having a major impact on results.

1.4.5 Social perception

Social cognition can provide insights into the impact of cognitive penetration since humans are highly dependent on their social networks. The neocortex, which is crucial for human cognition (Wagner & Luo, 2020), has its volume correlated with the size of the communities in primates (Dunbar, 1998). These findings support Dunbar's (1998) social brain hypothesis, where he proposes that the human neocortex evolution was socially guided. As we have seen, a high selective pressure must have been applied on the neural procedures behind face recognition(Nelson, 2001; Tsao et al., 2008) but the specific mechanisms in which we process the face stimuli percepts are still undisclosed. The integration of socially relevant information such as race and genre can modulate the visual processing paths (Adams & Kveraga, 2015), and Michel et al. (2006) found evidence for differential processing of faces with different races, which represents top-down influences on perception (Jenkin & Siegel, 2015; Kveraga et al., 2020). These influences on perception must be contemplated while researching face recognition and, consequently, the ORB, since our intuitive processing mechanisms can be influenced by our cognitive load (Adams & Kveraga, 2015).

Social categories can be filled with expectations and beliefs. Imagine a man with the belief that it is impossible for him to talk to blonde women. The simple sight of a bright hair in the distance can make this man shiver since the processing of low-level features such as luminance can be biased (Firestone & Scholl, 2015; Levin & Banaji, 2006). Levin and Banaji (2006) found that participants consistently considered black faces as darker even when luminance was controlled to match the luminance of white faces.

Adams and Kveraga (2015) argue that perception systems are informationally integrated and defy the modularity of the mind with research from the area of social perception. Their research scrutinises the influence of emotion and social categorisation on face processing and found that these can have a considerable repercussion on the judgment of emotion, other social cues and memory. They came up with an extensive model and argue that socially relevant information can modulate processing at early vision. The race is usually distinguished by a constellation of physical features (Glasgow et al., 2019) and this perceptual gestalt can lead to the early categorisation of the stimuli (Adams & Kveraga, 2015). For Adams and Kveraga (2015) this early categorisation represents the bottom-up integration of social cues.

Nonetheless, Adams and Kveraga (2015) do not determine processing states and are condemned for leaving the possibility of post perceptual influences. Toribio (2015) reminds Adams and Kveraga (2015) that, even with social properties influencing early stages of the perceptual experience, the evidence does not refute that high-level social contents are downstream of perception, revoking the assumption that perceptual experience contains high-level social properties. In any case, Toribio (2015) asserts that their data suggests the presence of some high-level emotional and social properties in the perceptual experience.

1.5 Our study

Hills and Lewis's (2011) work provides evidence that focusing on critical facial features can eradicate the ORB. Their study, explored the effects of shifting attention to distinctive facial features with a fixation cross directed either to the bottom or top half of the face stimuli.

They controlled the face features that received attention with two experiments where they placed fixation crosses that shifted the initial gazes. Their goal was to examine whether the ORB is moderated by the allocation of attention on features that could be more or less distinctive for that race (Hills & Lewis, 2011).

Hills and Lewis's (2011) results suggest that black faces are better recognised when the fixation cross is located to the bottom half of the face, a matter of perceptual expertise. Nonetheless, Wittwer et al. (2019) could not train participants to improve recognition by focusing on the bottom half of black faces.

As we have seen, there are several mechanisms to influence the allocation of attention. In Hills and Lewis's (2011) study, the fixation cross directs the focus of the initial gazes which controls the features that the participant attends first. However, given that category exemplars vary in their degree of typicality towards the category, it might be that not all black faces are better recognised by the features in the bottom half of the face. In the present work, we examine this question by manipulating typicality of all the face stimuli used. Given that social cognition research has identified the nose and the mouth as two features higly correlated with racial prototypicality (D. S. Ma, Koltai, et al., 2018, e.g.), we hypothesised that directing participants attention to these features will not benefit the recognition of these faces. In other word, we predict that the ORB will not be moderated by fixation cross location for more typical black faces. We further elaborate on these ideas below.

1.5.1 Distinctive features

Relying on the face-space model, Hills and Lewis (2011) verified that it is possible to train individuals in specific dimensions where other-race faces are more distinctive, and their results showed an attenuation of the ORB. Correll et al. (2017) argued that attention to race-specific and homogeneous facial features decreases resources to process other distinctive facial features. Some facial features can be more or less distinctive in certain races and people might use more appropriate cues for their race (Shepherd & Deregowski, 1981).

Hills and Lewis selected the mouth and the nose as more distinctive features for black faces, but these features might not be equally useful for all the faces. Typicality alters the distribution in the face-space model since it represents the variance in the category-indicative features. The mouth and the nose are usually indicative of an African race category (e.g. D. S. Ma, Koltai, et al., 2018). More typical African faces should be less distinctive in these features since they share more Afrocentric characteristics in their mouths and noses.

1.5.2 Indicative features

Research has not proposed a particular set of features that define a prototypical black face. Instead, there is a constellation of features that project a typical black face like full lips; wide noses; dark eye colour; coarse hair and dark complexion (Kleider-Offutt et al., 2017) with some features showing more relevance for the face prototypicality (D. S. Ma, Koltai, et al., 2018). How prototypical are the features on a certain face impact judgments (D. S. Ma, Correll, et al., 2018), affect the activation of stereotypes and are relevant for memory. Atypical CR faces are by themselves easier to recognise than typical CR faces, which are highly clustered in Valentine (1991) face-space (Byatt & Rhodes, 2004; S. G. Young et al., 2012).

1.5.3 Before we begin

Research in face processing points for differential processing of OR and CR faces. Yet, as we have seen, the extra perceptual influence on Hills and Lewis (2011) experiment only affects the first features that are attended and that should not affect the processing paths. So, their results are intriguing and should be further explored and debated. Hills and Lewis (2011) work is indeed valuable and provides the representational models with important data to understand the ORB. Nevertheless, this robust and complicated bias should be address in a expansive context, and the future experiments can be enhanced with input from recent work in Philosophy.

Chapter 2

Study 1

In Study 1, we assessed the racial prototypicality of a large set of face stimuli using a sample of Portuguese participants. Some facial features are associated with prototypical african/black faces such as wide noses, full lips and dark complexion (Kleider-Offutt et al., 2017). Hills and Lewis (2011) found that the nose and the mouth were distinctive features for recognising african/black faces and we propose that prototypicality of the stimuli can moderate the distinctiveness of the facial features. In fact, prototypicality is not often considered in face recognition studies and there are no data to be used for a Portuguese population.

Our goal was to select very typical and atypical black and white faces judged by a Portuguese sample in order to then examine our hypothesis in a second study.

2.1 Method

2.1.1 Participants

A sample of 130 participants (85 female, 42 male, 2 other, 1 did not report) took part in this experiment. The participants were recruited online, mostly caucasians (117 caucasian, 5 hispanic, 2 black and 6 other), and the average age of the sample was 26.54 (*SD* = 9.37).

2.1.2 Stimuli

Study 1 stimuli consisted in 320 digital photographs of faces (160 black and 160 white): 186 (93 black and 93 white) were selected from the Chicago face database (Ma et al., 2015); 24 (6 black and 18 white) from the NimStim face database (Tottenham et al., 2002); 38 (white) from the FACES database (Ebner et al., 2010); 25 (14 black and 11 white) from the MR2 face database (Strohminger et al., 2016); 31 (black) from the Meissner face database (Meissner et al., 2005); and 16 (black) from the Vital face database (Minear & Park, 2004). The use of different faces databases is recommended by Sergent (1986).

The photographs were coloured and displayed the central full face including hair, and a common white background. All faces were males with neutral expression and without distinctive markings. The images were presented in 72 dpi resolution, 134,8 mm wide x 116,4 mm high.

2.1.3 Procedure

The study was executed on Qualtrics. It started with a page of instructions where participants were informed that they would see a set of photographs of faces from several people that were either African (black) or Caucasian (white). The Participants were then asked to rate the faces on a 7-point scale ranging from atypical (1) to typical (7) for how representative the person was for the race/ethnic category. Participants were encouraged to look out for physical features in the faces that can be common for the race/ethnic category.

To ensure that participants were fully engaged, and to reduce fatigue the Survey had 5 versions, we created different study versions with 32 Black/African and 32 White/Caucasian different faces each. Each participant completed only one version of the study. Each version was completed by at least 25 participants. After rating all the 64 photographs, participants were asked their age, race, gender, if they completed the study alone, and if they took breaks during completion.

2.1.4 Results and discussion

Face ratings

We selected a total of 128 faces[1] to use in study 2: 32 typical of black (*M* = 6.42, *SD* = .09, *Min* = 6.28, *Max* = 6.60); 32 atypical of black (*M* = 4.43, *SD* = .63, *Min* = 2.85, *Max* = 5.19); 32 typical of white (*M* = 6.05, *SD* = .13, *Min* = 5.88, *Max* = 6.37); 32 atypical of white (*M* = 4.89, *SD* = .33, *Min* = 3.90, *Max* = 5.19). T-tests showed a significant difference in mean typicality ratings between typical and atypical black faces ($t(62) = 17.7$, $p < .001$, mean difference = 1.99) and between typical and atypical white faces ($t(62) = 18.6$, $p < .001$, mean difference = 1.16). An ANOVA on the mean ratings using race and typicality as between-subjects factors showed a significant interaction effect between these factors $F(1,124) = 41.94$, $p < .001$, $\eta_p^2 = .25$. Post-hoc t-tests within each race showed that this interaction is due a larger difference between typical and atypical black faces (Cohen's d = 5.48, 95% CI: 4.63 - 6.32) than between typical and atypical white faces (Cohen's d = 3.19, 95% CI: 2.55 - 3.82). There was also a large main effect of typicality, $F(1,124) = 600.44$, $p < .001$, $\eta_p^2 = .83$, and no main effect of race, $F(1,124) = 0.51$, $p = .478$, $\eta_p^2 = .004$. See appendix A for the means, standard deviations, and 95% confidence intervals associated with all 320 pre-tested faces.

Face measurements

Following D. S. Ma, Koltai, et al. (2018), we performed physical measurements of pictures of black and white faces. Particularly, we measured nose shape (distance between outside edge of the nose at widest point ÷ distance between nose tip and upper edge of eyes at nose tip center), lip fullness (distance between top and bottom edge of lips at thickest point ÷ distance between bottom of chin to edge of top of forehead/hairline), eye shape (distance between upper and lower inner eyelid at pupil center ÷ distance between inner and outer corner of eye), and eyebrow height (distance between top and bottom edge

[1] 80 faces (14 typical black, 23 atypical black , 20 typical white and 23 atypical white) belong to the Chicago face database (Ma et al., 2015); 11 (2 typical black, 3 atypical black , 1 typical white and 5 atypical white) to the NimStim face database (Tottenham et al., 2002); 13 (10 typical white and 3 atypical white) to the FACES database (Ebner et al., 2010); 7 (4 typical black, 1 atypical black , 1 typical white and 1 atypical white) to the MR2 face database (Strohminger et al., 2016); 13 (8 typical black and 5 atypical black) to the Meissner face database (Meissner et al., 2005); and 4 (typical black) to the Vital face database (Minear & Park, 2004)

Table 2.1: Descriptive analysis of several relevant face measures as a function of race following D. S. Ma, Koltai, et al. (2018).

Measure	Race	Mean	COD	95% Confidence Interval Lower	Upper
Nose Shape	Black	1.00	0.124	0.97	1.03
	White	0.886	0.14	0.86	0.92
Lip Fullness	Black	0.125	0.15	0.12	0.13
	White	0.0879	0.198	0.08	0.09
Eye Shape	Black	0.393	0.123	0.38	0.40
	White	0.416	0.127	0.40	0.43
Eyebrow height	Black	0.0478	0.137	0.046	0.049
	White	0.0432	0.148	0.042	0.045

of eyebrows at thickest point ÷ distance between bottom of chin to edge of top of forehead/hairline) given that these are the facial features likely cued by the fixation cross manipulation. By doing these measurements we were interested in assessing whether indeed black faces are more variable in the bottom half of the face in comparison with white faces and the other way around for the upper half of the face. Table 2.1 presents the mean measurements and coefficients of dispersion for these features as a function of face race. The coefficient of dispersion (COD) of each of these features is nearly identical between races. For the nose shape and lip fullness measurements, white faces have more variation relative to their mean, which contradicts previous research (Hills & Lewis, 2006, 2011).

In table 2.2 we can see that, as hypothesised by us, typical black faces are less disperse in nose shape and lip fullness than atypical black faces, and the reverse with eye shape. For white faces, we can also observe that typical faces are less disperse in nose shape that atypical ones, but not in lip fullness. Regarding the top half of white faces, we can see less dispersion for typical faces (vs. atypical) in the eye shape and in the eyebrow height. Thus, these results suggest that, in our sample of selected faces (128), the dispersion in the measurements of facial features is more affected by typicality than by race, which is consistent with the argument we present in the this thesis.

Table 2.2: Descriptive analysis of several relevant face measures as a function of race and typicality following D. S. Ma, Koltai, et al. (2018).

Measure	Race	Typicality	Mean	SD	95% Confidence Interval Lower	Upper
Nose Shape	Black	high	1.09	0.0855	1.06	1.12
		low	0.921	0.101	0.89	0.96
	White	high	0.871	0.102	0.84	0.91
		low	0.902	0.142	0.85	0.95
Lip Fullness	Black	high	0.135	0.0147	0.13	0.14
		low	0.115	0.0171	0.11	0.12
	White	high	0.0851	0.0176	0.08	0.09
		low	0.0906	0.0169	0.09	0.1
Eye Shape	Black	high	0.389	0.05	0.37	0.41
		low	0.398	0.0469	0.38	0.41
	White	high	0.408	0.0457	0.39	0.42
		low	0.424	0.0590	0.4	0.44
Eyebrow height	Black	high	0.0469	0.00645	0.045	0.049
		low	0.0487	0.00659	0.046	0.051
	White	high	0.0420	0.00606	0.040	0.044
		low	0.0444	0.00657	0.040	0.047

Chapter 3

Study 2

Study 2 tested whether the prototypicality of the faces moderate the results obtained by Hills and Lewis (2011), where they found that the ORB could be reduced by shifting attention to the most diagnostic features for the race. Following Hills and Lewis (2011) procedure, OR (white) and CR (black) faces were preceded by a fixation cross either between the eyes (high fixation cross) or in the tip of the nose (low fixation cross), both during the learning phase and the recognition phase. If the diagnostic features of the race are different for typical and atypical faces, then an attentional mechanism can't by itself explain the ORB.

3.1 Method

3.1.1 Participants

A sample of 91 white male undergraduate students from the Faculty of Psychology — University of Lisbon participated in this experiment in exchange for partial course credit. All had normal or corrected vision, were Portuguese and the mean age was 20.34 (*SD* = 4.9).

3.1.2 Apparatus and Stimuli

Study 2 stimuli was selected based on study 1 results and consisted in 128 digital photographs of faces[1] (32 typical black, 32 atypical black, 32 typical white and 32 atypical white): 80 (14 typical black, 23 atypical black , 20 typical white and 23 atypical white) were selected from the Chicago face database (Ma et al., 2015); 11 (2 typical black, 3 atypical black , 1 typical white and 5 atypical white) from the NimStim face database (Tottenham et al., 2002); 13 (10 typical white and 3 atypical white) from the FACES database (Ebner et al., 2010); 7 (4 typical black, 1 atypical black , 1 typical white and 1 atypical white) from the MR2 face database (Strohminger et al., 2016); 13 (8 typical black and 5 atypical black) from the Meissner face database (Meissner et al., 2005); and 4 (typical black) from the Vital face database (Minear & Park, 2004). The use of different faces databases is recommended by Sergent (1986).

All stimuli were presented on a high-resolution colour monitor. Participants responses were recorded on a standard keyboard. Stimuli layout was a central grayscale full face including hair, and a common white background. All faces were males with neutral expression and without distinctive markings. The images were presented in a 72 dpi resolution, 134,8 mm wide x 116,4 mm high. To avoid pictorial

[1] Details about the selected faces can be found on appendix A chapter.

recognition the stimuli were presented with a slight difference in luminosity and contrast between test and study phases (Bruce, 1982). Fixation crosses were 1 mm thick X 6 mm high X 6 mm wide black on white. These crosses locations were individually selected for each face in each condition (low and high fixation cross) to guarantee that the initial gazes were on the desired face features.

3.1.3 Design

All stimuli were preceded by a fixation cross, either in the upper portion of the face (high fixation cross) or in the lower portion of the face (low fixation cross), matched at learning and at test phases. The faces were either black or white and typical or atypical. This led to a 2x2x2 within subjects design. Faces were counterbalanced across participants so that each face appeared as a target and a distractor an equal number of times. Faces were counterbalanced across participants so that they were in each of the fixation cross conditions an equal number of times. The order of trials was completely randomised.

3.1.4 Procedure

This study employed Hills and Lewis (2011) old/new recognition paradigm with a few adaptations, which involved three consecutive phases: Learning, distraction and test. In the first phase participants were informed they would see a set of faces and were asked if they could distinguish the faces in a crowd, using a yes or no response. At this point, the participants were not informed of the subsequent recognition test. The participants were presented with 64 trials sequentially. Each trial consisted of a fixation cross presented for 200ms, followed by a face, followed by an interstimulus interval (ISI) presented for 100ms. The face appeared in the centre of the screen and remained on screen until the participant responded. The ISI was a plain white mask.

After the learning phase all participants filled out a distractor task. Subsequently, Participants started the test phase and were instructed that they would see another set of faces. Participants were instructed to state whether each face was one they had seen previously by pressing the appropriate keys on a computer keyboard. They were instructed to be as fast and as accurate as possible. There were 128 sequential recognition trials consisting of a fixation cross (presented for 200ms), a face (presented until response) and a ISI (presented for 100ms). The fixation cross appeared in the same position as in the learning phase. The presentation order of the trials in both phases was randomised. Finally, the participants were thanked and debriefed.

3.1.5 Results and discussion

As it is common practice in the literature, we calculated the signal detection estimates of Recognition sensitivity (A') and response criterion (B"; Macmillan & Creelman, 1991; Stanislaw & Todorov, 1999). A' is a nonparametric measure of sensitivity and reflects participants' ability to differentiate between target (studied face) and distractor (new face). This measure typically ranges from .5, indicating that target and distractor can't be distinguished, to 1, indicating ideal performance. The response criterion (B") is used to assess the response bias and can range from -1 to 1. If participants have the tendency to identify more faces as previously seen, they have a liberal response criterion, which results in positive B" values. In contrast, if participants have the tendency to identify more faces as new, they have a conservative response criterion, with negative B" values.

Recognition accuracy

A 2 (typicality: high vs low) X 2 (fixation cross: nose vs eyes) X 2 (face race: black vs white) repeated measures ANOVA on A' values revealed a significant effect of face race, $F(1,90) = 44.64$, $p < .001$, $\eta_p^2 = .332$, participants correctly recognised more accurately white faces ($M = .772$, $SE = .01$) than black faces ($M = .704$, $SE = .01$). The main effect of typicality was also significant, $F(1,90) = 72.34$, $p < .001$, $\eta_p^2 = .446$, where low typicality faces were better recognised ($M = .790$, $SE = .0103$) than high typicality faces ($M = .686$, $SE = .0103$). The main effect of fixation cross was not significant , $F(1,90) = 1.103$, $p = .296$, $\eta_p^2 = .012$. This is inconsistent with Hills and Lewis's (2011) results but the interaction between face race and fixation cross was also not significant, $F(1,90) = .582$, $p = .447$, $\eta_p^2 = .006$, contrary to Hills and Lewis (2011). Analysing the interaction between face race, fixation and typicality, $F(1,90) = 1.205$, $p = .275$, $\eta_p^2 = .013$, we found little resemblance to Hills and Lewis's (2011) effects. Although the three-way interaction was not significant, looking at the figure 3.1 bellow, it seems that recognition for white faces was better with the nose fixation cross, and in both races high typical faces had similar recognition on different fixation cross conditions.

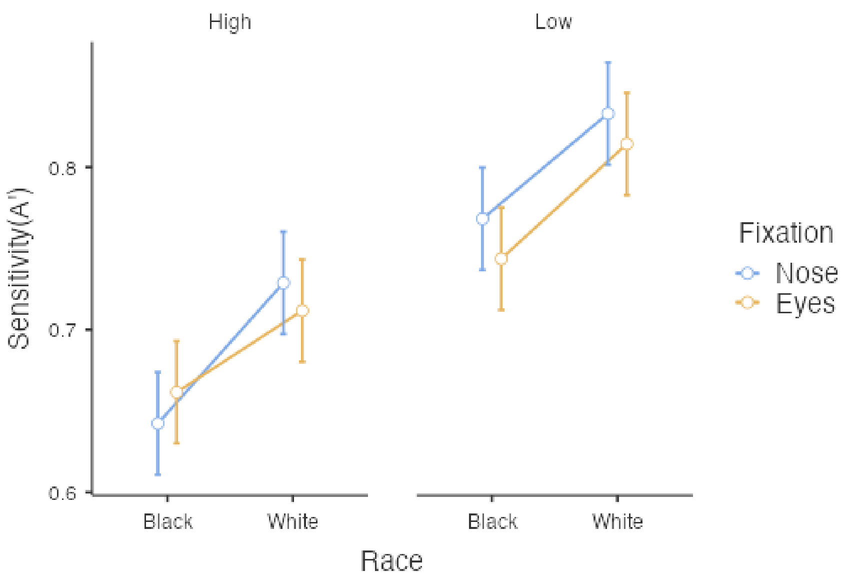

Figure 3.1: Graphical representation of the three-way interaction between face race, fixation and typicality

Response criterion

A 2 (typicality: high vs low) X 2 (fixation cross: nose vs eyes) X 2 (face race: black vs white) repeated measures ANOVA on B" scores revealed a significant effect of face race, $F(1,90) = 6.73$, $p = .011$, $\eta_p^2 = .070$, participants were more liberal about black faces ($M = -.106$, $SE = .00237$) than white faces ($M = .172$,
$SE = .00237$). The main effect of typicality was also significant, $F(1,90) = 18.613$, $p < .001$, $\eta_p^2 = .171$, where low typicality faces were biased for more conservative responses ($M = -.184$, $SE = .0226$) and high typicality faces for more liberal responses ($M = -.093$, $SE = .0226$). The main effect of fixation cross was not significant , $F(1,90) = 1.84$, $p =.178$, $\eta_p^2 = .02$.

False alarms

A 2 (typicality: high vs low) X 2 (fixation cross: nose vs eyes) X 2 (face race: black vs white) repeated measures ANOVA on participants false alarms data revealed a significant effect of face race, $F(1,90) = 31.189$, $p < .001$, $\eta_p^2 = .257$, since participants were more liberal about black faces, false alarms were more frequent ($M = 2.32$, $SE = .114$) compared to white faces ($M = 1.64$, $SE = .114$). The main effect of typicality was also significant, $F(1,90) = 127.294$, $p < .001$, $\eta_p^2 = .586$, where high typicality faces had more false alarms ($M = 2.52$, $SE = .108$) than low typicality faces ($M = 1.44$, $SE = .108$). No other effect was significant.

Hits

A 2 (typicality: high vs low) X 2 (fixation cross: nose vs eyes) X 2 (face race: black vs white) repeated measures ANOVA on participants hits values revealed a significant interaction between face race and typicality, F(1,90) = 8.33.,p = .005, $\eta_p^2 = .085$, atypical white faces were better recognised (see table 3.1).

Table 3.1: Estimated Marginal Means - Race * Typicality

				95% Confidence Interval	
Typicality	**Race**	**Mean**	**SE**	**Lower**	**Upper**
High	Black	4.66	0.161	4.35	4.98
	White	4.65	0.161	4.33	4.97
Low	Black	4.73	0.161	4.41	5.05
	White	5.26	0.161	4.94	5.58

Response times

A 2 (typicality: high vs low) X 2 (fixation cross: nose vs eyes) X 2 (face race: black vs white) repeated measures ANOVA on participants response times values revealed no significant effect in the reaction time data.

Chapter 4

Discussion

In the current dissertation, we replicated the ORB, and atypical stimuli were better recognised. However, shifting attention to the nose/mouth of black faces did not improve recognition. Similarly, there was no significant evidence to support our hypothesis that the lower face features were bad distinctive features for typical black faces.

4.1 Typicality

Study 1 was necessary to test the initial hypothesis. We wanted to use different face databases and their typicality needed to be appraised for the Portuguese population.

After performing the face measurements we had good indicators for our hypothesis, since typical black faces had less variability in the lower face features (nose shape; lip fullness) which was part of our predictions. This physical variability should bring less distinctive information about the face when the fixation cross was lower, resulting in poorer recognition.

In study 2 typical black faces were better recognised with a high fixation cross and all white faces were better recognised with a low fixation cross but the interaction was not significant. Memory was better and response criterion was more conservative for atypical faces. The ORB is usually characterised by a liberal response criterion in the case of CR faces. However, it also displayed a lower number of false alarms for atypical CR faces.

Following Santi et al. (2016), atypical faces are harder to categorise which can result in more individuation and better recognition (Tanaka & Corneille, 2007). Nevertheless, atypical white faces were the ones with better recognition results, providing evidence that the ORB can be found even around an atypical stimuli set.

4.2 How to explain the own-race bias?

In study 2, white faces were better recognised and judged in a more conservative response criterion. These results were expected since we replicated the ORB. Nevertheless, it is not clear what mechanisms handle the ORB and our data is not useful to expand the knowledge about the attentional mechanism reported by Hills and Lewis (2011).

Hills and Lewis's (2011) results are coherent with perceptual expertise models. In their study, the scanning pattern useful for face recognition is different across races. Hills and Lewis's (2011) focus on the physical properties that are more useful to recognise a sample of faces and reason that increased expertise enhances the ability to pay attention to distinctive features.

However, research suggests that holistic processing is more efficient, which is incongruent with selecting a set of physical features to allocate attention. Associating social information to the perceptual information can improve face recognition (Schwartz & Yovel, 2019). In fact, according to Rossion (2013) the composite face paradigm is proof that a human face cannot be perceived divided in its features.

Granted that face processing strategies can be diverse among humans, and that some feature based strategies can be efficient, looking for racial distinctive facial features is always a simplification.

Burgund (2021) shows that increased time looking at the eyes predicts better recognition for all races. Black faces recognition is also improved with increased time looking at the nose/mouth (Burgund, 2021). Still, training participants to attend the nose/mouth of black faces does not guarantee improved recognition (Wittwer et al., 2019).

In fact, shifting the initial attention can not ensure a specific scan pattern, since the nose/mouth features can also direct attention to other racial indicative features, to confirm a categorisation (Raftopoulos, 2019; Wittwer et al., 2019). Stelter et al. (2021) measured gaze fixations to facial features during a recognition task and found that the differences in attention allocation to the eyes of CR and OR occur in recognition phase and might induce inter-group biases (Correll & Hudson, 2020). Familiarity with a face will increase recognition, but the critical features for recognition are the same for familiar and unfamiliar faces (Abudarham et al., 2019; Abudarham & Yovel, 2019).

CR faces recognition requires more than selecting the specific distinctive features. Despite the relevance of such features (Hills & Lewis, 2006, 2011), a racial group is too diverse to generalise. Expertise can improve perceptual acuity (Siegel, 2020), allowing minor differences to be noticed, but repetition does not guarantee improved recognition (Palma & Garcia-Marques, 2020).

Perceptual expertise models are corroborated with significant experimental data, providing strong justifications for the ORB effects. Nevertheless, an integrated research experience would be a valuable addition for these models.

Race is a social category that we learn from an early age (Kawakami et al., 2018). The boundaries are not clear (Glasgow et al., 2019) but stereotypes are rooted in our cultural background, and we are capable of extracting this social category immediately from a facial stimulus, which can influence the regard and motivation to individuate.

As social beings, we value the groups that we belong to, and they can impact our memory. ”We-all” words exist in every language (Goddard & Wierzbicka, 2021) and are the linguistic representation of the in-group. These in-groups are fundamental to human life and seem to be universal in social cognition and language (Goddard & Wierzbicka, 2021).

4.3 Distinctive features

We could not find any evidence of the distinctive features pointed by Hills and Lewis (2011) for black faces. Study 2 results showed no resemblance to Hills and Lewis's (2011) results and, after performing the physical measurements, the variability of each feature was identical between races.

Our goal was to investigate the boundaries of the effect. We suspected that distinctive features for a complex social category such as black faces should be more variable than what was described by Hills and Lewis (2011). We also believed that typical black faces would have similarities in these distinctive features.

Our results showed no indication of an attentional mechanism for first gazes present in the ORB. Such mechanism would impact early vision but there is no evidence that it would modify late vision processing (Raftopoulos, 2019).

In fact, Hills and Lewis (2011) feature selection could activate a category verification, since these features can suggest a racial category membership, that would need to be confirmed (Raftopoulos, 2019). The stimuli is then considered a member of that group instead of an individual in its own right, which can increase the ORB (Wittwer et al., 2019).

Burgund (2021) highlights the importance of the eyes for face recognition but also indicates the nose/mouth as specific distinctive features for black faces. Yet, face recognition relies on the eye region for individuation and memory (Royer et al., 2018). Attention on the eye region can enhances the performance in face recognition tasks (Peterson & Eckstein, 2012) but these results are not always present (Correll & Hudson, 2020).

It seems counter intuitive to look for distinctive features in something that is often processed in a holistic way (Rossion, 2013), but it is even harder to do so for a big social group. Black people share the darker skin, nevertheless, their variability in face features is unpredictable (Glasgow et al., 2019). If we look at the African continent, it is easy to understand that the diversity of the Humans living there will be complex, with several ethnic groups. Mixed-race individuals are also easily considered black providing more complexity on the quest to find the distinctive features for black faces.

4.4 Replication value

Replication is necessary in science. Verifying results or hypotheses is the core of scientific work (Schmidt, 2016) and increases the value of the knowledge gathered by scientific experiments.

Nevertheless, in Baker's (2016) survey, more than 70% of researchers affirm to have failed to reproduce an experiment and 52% state that we are encountering a significant crisis. Open Science Collaboration et al. (2015) carried out replications of 100 psychology experiments. From those, 39% could replicate the original results.

There are several possible explanations for these numbers and Stroebe et al. (2012) examined examples of fraud cases. Obvious malpractices are thoroughly discussed but questionable research practices (QRPs) are probably more significant (John et al., 2012).

QRPs are not flagrantly inadmissible but enhance the chances of finding a significant effect (Simmons et al., 2011). Research with significant results is easier to publish so these QRPs are actually stimulated instead of chastised (Earp & Trafimow, 2015; Fidler & Wilcox, 2021). This publication bias leads researchers to forget their own studies which do not yield significant results (Earp & Trafimow, 2015).

Direct replication studies are uncommon due to the lack of support and prestige (Collaboration et al., 2015; Earp & Trafimow, 2015; Fidler & Wilcox, 2021). In general, replication studies are hard to decipher. Replicating effects might happen due to hidden artefacts, and failed replications do not falsify the original experiment. Nevertheless, a replication can be highly informative.

Our experiment was a conceptual replication with significant differences in stimuli and design. It was meant to bring more information to the debate around Hills and Lewis's (2011) findings. However, just like Wittwer et al. (2019) we could not replicate.

There are several possible justifications, such as differences in the face stimuli, manipulations related with typicality or different participants cultural background. Simhi and Yovel (2020) critics the use of static faces, since we associate faces with a dynamic person, filled with other nuances that can facilitate recognition.

A perfect replication demands highly detailed procedures and might end up replicating artefacts (Earp & Trafimow, 2015). Even so, not all steps can be verbalised and some might even not be necessary for a successful replication. An experiment will never be replicated with perfection since even a difference in population of participants can affect results.

In our case, Portugal is a country rich with African immigrants due to its colonial past. Our sample of participants will likely differ from Hills and Lewis's (2011) sample, since their participants reported to not have significant contact with black individuals. However, Portugal has a different African genetic pool compared to the United Kingdom, and the contact is most likely conditioned by socioeconomic factors. This kind of cultural difference can decrease the quality of the replication (Schmidt, 2016).

Failing to replicate Hills and Lewis (2011) doesn't falsify their results, but it indicates that we should explore the context where this data is verified. In conclusion, we are facing a moment where it is possible to improve our methods and practices. Even if these changes affect our productivity and creativity, the rate of scientific progress is prone to increase (Vazire, 2018).

Chapter 5

Conclusion

Humans are proficient at face recognition, and our society counts on that. Nevertheless, the mechanisms behind our capabilities memorising faces can be unpredictable. Effects as the ORB, which substantially decreases memory performance, have consequences and are important in real life. An eyewitness can be sure of a biased recognition (Davies, 1996), making us wonder how reliable is our memory.

In this dissertation, there was no evidence to explore an attentional mechanism for distinctive features on different racial groups. Such effects will probably depend on the sample. Nonetheless, shifting attention to distinctive features seems to be insufficient to induce the holistic processing of faces.

Typicality affected memory, but it did not help us predict differences in the distinctive features. We can improve experimental designs, fewer studied faces can reduce the cognitive load of the experiment and increase familiarity. Studies with women and black participants are uncommon and an interesting experimental design alternative that could also help us understand Hills and Lewis (2011) effect. A direct replication would also be informative to investigate the significance of Hills and Lewis's (2011) results.

Considering Hills and Lewis's (2011) reflections, common scan pattern seems insufficient for the variability in black faces. In fact, scan patterns are unique to each participant(Mehoudar et al., 2014). Distinctive features for a certain race imply a biological justification to that group. If we follow Glasgow et al. (2019), there is no reason for a cultural, social or political group to share distinctive facial features.

Our research field demands an updated view on what is race, how do we learn it as a social category, and when do we categorise a face. The ORB is an effect where categorisation is fast and can affect motivation. This might be useful in cognitive penetration research (Adams & Kveraga, 2015).

In conclusion, this dissertation points to the urgency of collaboration around the research on the ORB. Both social cognition and perceptual expertise models can be more flexible. Hybrid models such as the CIM can provide new insights and grow with cooperation, while research in Philosophy can guide improvements to our experimental designs.

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Appendix A

Appendix chapter

Table A.1: Results of study 1 for all 320 pre-tested faces. BM stands for black male and WM for white male. Light purple background cells were selected as typical faces and dark purple background cells were selected as atypical faces. ML stands for median luminance and was measured using the skin area in Adobe Photoshop. Lower ML means darker skin tone. The other measures are explained in the results section of study 1.

Faces	Sample size	Average typicality	Standard Deviation	95%CI Upper Bound	95%CI Lower Bound	ML	Nose Shape	Lip Fullness	Eye Shape	Eyebrow Height
BM39	25	6.600	0.816	6.920	6.280	88	1.117	0.1493	0.3482	0.04756
BM69	29	6.586	0.628	6.815	6.358	84	1.084	0.1486	0.4356	0.04651
BM133	26	6.577	0.902	6.924	6.230	80	1.076	0.1412	0.4000	0.03102
BM51	27	6.556	0.698	6.819	6.292	79	1.042	0.1318	0.3243	0.04436
BM127	26	6.538	0.761	6.831	6.246	84	1.105	0.1454	0.4202	0.03517
BM103	26	6.538	0.859	6.869	6.208	88	0.981	0.1307	0.4414	0.04472
BM110	27	6.519	0.935	6.871	6.166	89	1.159	0.1337	0.3077	0.05346
BM124	27	6.519	1.156	6.955	6.082	83	0.963	0.1299	0.4154	0.04978
BM46	26	6.500	1.175	6.952	6.048	82	1.144	0.1615	0.3107	0.04342
BM151	29	6.483	0.688	6.733	6.232	95	1.058	0.1247	0.4513	0.05196
BM81	26	6.462	1.208	6.926	5.997	95	1.146	0.1245	0.3063	0.05256
BM134	26	6.462	0.859	6.792	6.131	95	1.164	0.1053	0.3719	0.04479
BM148	26	6.423	0.809	6.734	6.112	90	1.345	0.1385	0.3458	0.04749
BM96	29	6.414	0.780	6.698	6.130	92	1.075	0.1515	0.4867	0.04970
BM63	29	6.414	1.086	6.809	6.018	77	1.125	0.1302	0.3679	0.05541
BM30	29	6.414	0.682	6.662	6.165	94	1.040	0.1250	0.4314	0.05316
BM158	29	6.414	0.733	6.680	6.147	90	1.075	0.1651	0.3197	0.05081
BM101	29	6.414	0.907	6.744	6.084	88	1.063	0.1307	0.4628	0.03416
BM91	26	6.385	0.637	6.630	6.140	95	0.983	0.1086	0.3750	0.04318
BM41	26	6.385	0.898	6.730	6.039	92	1.023	0.1295	0.3276	0.04116
BM8	26	6.385	0.983	6.762	6.007	88	1.085	0.1338	0.3824	0.06043
BM146	25	6.360	1.319	6.877	5.843	83	1.068	0.1234	0.3922	0.04583
BM122	25	6.360	1.411	6.913	5.807	81	1.227	0.1424	0.4068	0.04118
BM21	26	6.346	1.384	6.878	5.814	85	0.944	0.1160	0.3981	0.04897
BM160	26	6.346	1.263	6.832	5.861	57	1.028	0.1515	0.3966	0.04018
BM95	29	6.345	1.045	6.725	5.965	84	1.094	0.1376	0.4831	0.04803

Table A.1 continued from previous page

BM102	25	6.320	0.988	6.707	5.933	110	1.206	0.1601	0.3853	0.05501
BM116	29	6.310	0.761	6.587	6.033	81	1.066	0.1493	0.3966	0.05093
BM15	26	6.308	1.192	6.766	5.849	83	1.051	0.1230	0.3905	0.04189
BM76	27	6.296	1.235	6.762	5.831	91	1.042	0.1223	0.3364	0.05053
BM34	28	6.286	1.410	6.808	5.763	100	1.194	0.1399	0.4158	0.05163
BM141	25	6.280	1.208	6.754	5.806	91	0.949	0.1193	0.4094	0.04447
BM54	26	6.269	1.430	6.819	5.720	89	1.171	0.1330	0.4149	0.05092
BM142	27	6.259	0.944	6.615	5.903	82	1.012	0.1209	0.3782	0.04930
BM3	26	6.231	1.243	6.708	5.753	114	1.011	0.1410	0.3178	0.04701
BM121	26	6.231	1.032	6.627	5.834	88	1.237	0.1160	0.3538	0.05006
BM25	25	6.200	1.080	6.623	5.777	82	0.954	0.1341	0.4257	0.05469
BM29	26	6.192	1.167	6.641	5.744	102	1.078	0.1202	0.4043	0.04102
BM117	26	6.192	1.470	6.757	5.627	74	1.048	0.1309	0.4098	0.04740
BM107	27	6.185	1.039	6.577	5.793	75	1.248	0.1314	0.4174	0.04182
BM149	29	6.172	0.805	6.465	5.879	80	1.166	0.1486	0.3362	0.04608
BM71	26	6.154	1.434	6.705	5.603	105	1.041	0.1639	0.4286	0.04097
BM140	26	6.154	0.925	6.509	5.798	94	1.118	0.1448	0.4414	0.03763
BM114	26	6.154	1.461	6.716	5.592	72	1.249	0.1256	0.3966	0.03425
BM2	27	6.148	1.064	6.549	5.747	89	1.250	0.1319	0.3796	0.04961
BM84	29	6.138	0.915	6.471	5.805	99	1.167	0.1235	0.3936	0.04252
BM14	26	6.115	0.952	6.481	5.749	99	0.761	0.1102	0.3824	0.05118
BM26	26	6.115	1.558	6.714	5.517	100	1.164	0.1117	0.3229	0.04966
BM85	26	6.115	1.243	6.593	5.637	104	0.963	0.0819	0.4299	0.03969
BM1	26	6.115	1.451	6.673	5.558	101	1.209	0.1459	0.3761	0.05388
BM135	26	6.115	1.211	6.581	5.650	83	0.913	0.0897	0.4336	0.03380
BM33	27	6.111	1.121	6.534	5.688	107	1.125	0.1331	0.3667	0.04958
BM153	26	6.077	1.262	6.562	5.592	88	1.143	0.1420	0.3929	0.04359
BM80	27	6.074	1.035	6.464	5.684	109	0.950	0.1434	0.4231	0.04781
BM129	27	6.074	0.874	6.404	5.744	102	0.883	0.1373	0.3947	0.03922
BM128	27	6.074	0.958	6.435	5.713	108	1.031	0.1358	0.3566	0.05048
BM56	29	6.069	0.961	6.419	5.719	106	0.968	0.1263	0.3304	0.04255
BM130	26	6.038	1.076	6.452	5.625	97	0.949	0.1153	0.3786	0.05111
BM17	27	6.037	1.285	6.522	5.552	95	1.028	0.1125	0.4100	0.05183
BM105	29	6.034	1.017	6.405	5.664	93	1.054	0.1417	0.3529	0.05118
BM152	29	6.034	1.052	6.417	5.652	88	0.974	0.1306	0.4359	0.03795
BM100	27	6.000	1.074	6.405	5.595	117	1.029	0.1434	0.3238	0.04167
BM16	26	6.000	1.356	6.521	5.479	98	1.023	0.1147	0.3853	0.04863
BM5	27	6.000	1.240	6.468	5.532	96	1.035	0.1346	0.4021	0.05513
BM19	29	6.000	1.035	6.377	5.623	109	1.123	0.1637	0.4667	0.04195
BM65	29	6.000	1.102	6.401	5.599	95	1.095	0.1046	0.3131	0.05160
BM32	29	6.000	0.886	6.323	5.677	100	1.117	0.1147	0.3303	0.04694
BM139	26	6.000	1.233	6.474	5.526	92	1.093	0.1056	0.4370	0.04654
BM22	29	5.966	1.210	6.406	5.525	97	0.957	0.1405	0.3271	0.04768
BM111	27	5.963	1.315	6.459	5.467	94	1.037	0.1582	0.4423	0.05228
BM42	27	5.963	1.224	6.425	5.501	113	1.193	0.1110	0.2818	0.04330
BM159	27	5.963	1.454	6.511	5.415	84	1.070	0.1624	0.3893	0.04378
BM126	26	5.962	1.280	6.454	5.470	80	0.872	0.1090	0.4636	0.03859

Table A.1 continued from previous page

BM36	26	5.962	1.148	6.403	5.520	91	1.037	0.1228	0.3883	0.05388
BM12	26	5.962	1.399	6.499	5.424	116	1.000	0.1176	0.3860	0.06022
BM113	26	5.962	1.183	6.416	5.507	97	1.314	0.1452	0.3277	0.05152
BM154	25	5.960	1.485	6.542	5.378	74	0.920	0.1043	0.3879	0.03968
BM143	25	5.960	1.428	6.520	5.400	82	0.849	0.1304	0.3468	0.03593
BM24	26	5.923	1.164	6.370	5.476	92	0.969	0.1327	0.3846	0.04336
BM57	25	5.920	1.470	6.496	5.344	86	0.961	0.1054	0.4318	0.04875
BM13	25	5.920	1.187	6.385	5.455	99	0.990	0.0923	0.4563	0.05332
BM77	27	5.889	1.188	6.337	5.441	100	1.050	0.1515	0.3423	0.04826
BM43	29	5.862	1.187	6.294	5.430	89	1.021	0.1407	0.3474	0.05850
BM104	29	5.862	0.953	6.209	5.515	128	1.044	0.1323	0.4206	0.05243
BM58	26	5.846	1.377	6.375	5.317	96	0.889	0.1224	0.3750	0.05469
BM109	26	5.846	1.377	6.375	5.317	100	1.102	0.1557	0.3248	0.05068
BM73	26	5.846	1.287	6.341	5.352	105	0.973	0.1214	0.3704	0.05204
BM92	25	5.840	1.106	6.274	5.406	127	0.932	0.1528	0.4646	0.05457
BM55	29	5.828	1.311	6.305	5.350	109	0.869	0.1408	0.3619	0.04424
BM35	27	5.815	1.075	6.220	5.409	110	1.006	0.1757	0.4271	0.05160
BM44	27	5.815	1.178	6.259	5.371	95	1.058	0.1495	0.3846	0.04681
BM87	26	5.808	1.096	6.229	5.386	101	0.905	0.1121	0.3271	0.04954
BM48	26	5.808	1.443	6.362	5.253	99	1.058	0.1373	0.3860	0.05114
BM86	27	5.778	1.121	6.201	5.355	111	1.079	0.1413	0.4224	0.05540
BM67	26	5.769	1.177	6.222	5.317	116	0.932	0.1170	0.3874	0.04551
BM37	25	5.760	1.052	6.172	5.348	110	0.978	0.1215	0.4757	0.05570
BM72	26	5.731	1.614	6.351	5.110	105	0.970	0.1142	0.4479	0.04593
BM28	26	5.731	1.485	6.302	5.160	100	1.146	0.1156	0.3578	0.05242
BM6	27	5.704	1.137	6.133	5.275	104	0.817	0.1402	0.3761	0.05607
BM123	26	5.692	1.225	6.163	5.221	132	0.900	0.1200	0.4264	0.05625
BM120	26	5.692	1.490	6.265	5.119	103	0.971	0.1463	0.3750	0.04317
BM119	26	5.692	1.158	6.138	5.247	109	0.964	0.1501	0.4711	0.04342
BM82	25	5.680	1.376	6.219	5.141	98	0.897	0.1136	0.3925	0.04494
BM89	25	5.680	1.215	6.156	5.204	121	0.929	0.1345	0.4054	0.04348
BM31	25	5.680	1.626	6.317	5.043	92	1.017	0.1574	0.4107	0.04735
BM112	25	5.680	1.215	6.156	5.204	100	1.139	0.1241	0.3796	0.04258
BM137	26	5.654	1.198	6.114	5.193	90	0.916	0.1292	0.4369	0.04382
BM99	26	5.654	1.573	6.259	5.049	85	0.963	0.1140	0.4554	0.04922
BM4	25	5.640	1.350	6.169	5.111	115	0.660	0.1160	0.4022	0.03009
BM125	26	5.615	1.023	6.009	5.222	120	0.834	0.1206	0.4352	0.05473
BM106	29	5.552	1.378	6.053	5.050	99	1.028	0.1324	0.3707	0.04762
BM18	27	5.519	1.424	6.056	4.981	107	0.936	0.1032	0.4848	0.05162
BM115	26	5.500	1.476	6.068	4.932	99	0.962	0.1252	0.3148	0.03953
BM10	25	5.480	1.558	6.091	4.869	98	0.917	0.1417	0.3646	0.05586
BM157	26	5.423	1.270	5.911	4.935	97	1.039	0.1254	0.3525	0.04329
BM144	26	5.423	1.238	5.899	4.947	112	0.835	0.1044	0.3985	0.03715
BM108	29	5.414	1.150	5.832	4.995	121	0.865	0.1249	0.3805	0.04901
BM40	25	5.400	1.443	5.966	4.834	98	0.939	0.1231	0.4095	0.05315
BM66	26	5.385	1.416	5.929	4.840	118	0.792	0.1198	0.4188	0.06479
BM7	29	5.379	1.545	5.942	4.817	105	1.058	0.1416	0.3587	0.04578

Table A.1 continued from previous page

BM156	27	5.370	1.621	5.982	4.759	135	0.964	0.1253	0.4472	0.04063
BM52	25	5.360	1.381	5.901	4.819	129	1.006	0.1389	0.3739	0.02937
BM136	27	5.333	1.271	5.813	4.854	135	0.904	0.1210	0.3707	0.04110
BM78	25	5.280	1.308	5.793	4.767	132	1.115	0.1592	0.3805	0.04789
BM79	26	5.269	1.251	5.750	4.788	138	0.871	0.1462	0.3717	0.04569
BM83	27	5.259	1.318	5.757	4.762	108	1.111	0.1328	0.3878	0.05149
BM145	29	5.241	1.272	5.704	4.778	104	0.951	0.1303	0.4472	0.05486
BM147	26	5.231	1.773	5.912	4.549	105	0.947	0.1072	0.4322	0.04458
BM47	26	5.192	1.415	5.736	4.648	119	0.971	0.1209	0.3762	0.04291
BM94	27	5.185	1.545	5.768	4.602	117	0.784	0.1362	0.4786	0.05316
BM132	29	5.138	1.125	5.547	4.728	105	1.034	0.1106	0.3525	0.03448
BM75	25	5.120	1.691	5.783	4.457	127	0.983	0.1148	0.4167	0.04482
BM138	26	5.038	1.341	5.554	4.523	128	0.978	0.1415	0.3577	0.04258
BM98	29	4.966	1.149	5.384	4.547	121	0.940	0.1146	0.3964	0.04338
BM11	27	4.963	1.581	5.559	4.367	106	0.850	0.1320	0.4019	0.03686
BM90	26	4.923	1.440	5.477	4.370	118	0.971	0.1517	0.4301	0.05503
BM50	26	4.923	1.521	5.508	4.338	98	0.908	0.0954	0.3333	0.04839
BM68	26	4.923	1.719	5.584	4.262	132	1.017	0.0935	0.3895	0.05089
BM155	25	4.920	1.320	5.438	4.402	132	0.951	0.1312	0.4364	0.04496
BM93	26	4.846	1.759	5.522	4.170	101	0.828	0.1320	0.4259	0.04933
BM88	26	4.808	1.600	5.423	4.192	135	0.833	0.1137	0.4153	0.04598
BM64	26	4.692	1.594	5.305	4.080	105	1.189	0.1147	0.3564	0.05175
BM49	27	4.630	1.497	5.194	4.065	133	0.852	0.1286	0.4643	0.04918
BM70	29	4.621	1.237	5.071	4.171	130	1.098	0.1162	0.3465	0.03922
BM97	29	4.586	1.659	5.190	3.983	109	0.932	0.1150	0.3697	0.05988
BM150	27	4.519	1.626	5.132	3.905	150	0.920	0.1001	0.3524	0.04396
BM59	25	4.440	1.828	5.156	3.724	123	0.764	0.0960	0.4673	0.05829
BM53	29	4.345	1.289	4.814	3.876	127	0.931	0.0742	0.3737	0.05078
BM20	27	4.296	1.436	4.838	3.755	133	1.035	0.1142	0.4175	0.05457
BM62	29	4.241	1.527	4.797	3.686	133	0.810	0.1074	0.3571	0.06309
BM38	26	4.154	1.541	4.746	3.561	111	0.912	0.1085	0.4182	0.05572
BM60	29	4.103	1.877	4.787	3.420	138	0.823	0.1315	0.4059	0.04755
BM23	27	3.926	1.207	4.381	3.471	127	0.889	0.1233	0.4375	0.05349
BM27	25	3.920	1.824	4.635	3.205	136	0.955	0.1230	0.4364	0.05217
BM9	26	3.846	1.666	4.487	3.206	132	0.798	0.1010	0.3786	0.05052
BM45	26	3.654	1.325	4.163	3.145	137	0.896	0.1164	0.3866	0.05006
BM131	25	3.560	1.121	3.999	3.121	157	0.962	0.0994	0.4758	0.04099
BM118	26	3.269	1.845	3.978	2.560	174	1.021	0.1396	0.3415	0.04767
BM74	25	3.240	1.480	3.820	2.660	163	0.919	0.0914	0.2832	0.05485
BM61	27	2.852	1.460	3.402	2.301	124	0.719	0.0967	0.4587	0.04337
WM94	27	6.370	0.792	6.669	6.072	179	1.006	0.1118	0.4071	0.03571
WM15	26	6.308	1.192	6.766	5.849	157	0.886	0.0818	0.4545	0.05228
WM71	26	6.269	1.002	6.655	5.884	181	0.972	0.1009	0.3235	0.03746
WM46	26	6.192	1.201	6.654	5.731	181	0.864	0.0979	0.4466	0.04414
WM129	27	6.185	1.039	6.577	5.793	168	0.856	0.0682	0.4602	0.03815
WM11	26	6.154	0.834	6.474	5.833	165	0.860	0.0742	0.2870	0.04503
WM74	26	6.154	1.120	6.585	5.723	187	0.857	0.0920	0.3918	0.05440

Table A.1 continued from previous page

WM109	26	6.115	1.177	6.568	5.663	181	1.052	0.1073	0.3761	0.04152
WM133	26	6.115	1.275	6.606	5.625	184	0.844	0.0580	0.4078	0.03453
WM144	26	6.115	1.211	6.581	5.650	160	0.862	0.1007	0.4037	0.03477
WM28	26	6.115	1.107	6.541	5.690	185	0.837	0.1021	0.4135	0.03876
WM81	26	6.115	1.211	6.581	5.650	177	0.854	0.0663	0.3895	0.04696
WM58	26	6.077	1.262	6.562	5.592	174	0.822	0.0599	0.3478	0.03216
WM76	26	6.077	1.129	6.511	5.643	191	0.887	0.0996	0.4845	0.03903
WM42	27	6.074	1.107	6.492	5.657	169	0.854	0.0817	0.4300	0.03659
WM25	25	6.040	1.207	6.513	5.567	160	0.759	0.0909	0.4479	0.05132
WM131	26	6.038	1.311	6.542	5.535	167	1.044	0.0532	0.4271	0.05029
WM153	26	6.038	1.183	6.493	5.584	178	0.865	0.0839	0.4227	0.04980
WM10	25	6.000	1.155	6.453	5.547	160	0.769	0.0648	0.3800	0.04318
WM21	26	6.000	1.131	6.435	5.565	158	0.818	0.0731	0.4167	0.04825
WM26	26	6.000	1.497	6.575	5.425	172	0.807	0.0750	0.4900	0.03026
WM156	27	5.963	1.344	6.470	5.456	160	1.143	0.0693	0.4667	0.03943
WM12	26	5.962	1.399	6.499	5.424	186	0.742	0.0902	0.4206	0.04098
WM130	26	5.962	1.612	6.581	5.342	165	0.915	0.1201	0.4000	0.04096
WM150	27	5.926	1.035	6.316	5.536	178	1.000	0.1037	0.3700	0.03806
WM4	27	5.926	1.357	6.438	5.414	146	0.871	0.0754	0.3333	0.04681
WM141	26	5.923	1.093	6.343	5.503	165	0.914	0.0657	0.3784	0.03965
WM3	26	5.923	1.440	6.477	5.370	158	0.648	0.1066	0.3861	0.04348
WM20	27	5.889	1.311	6.383	5.394	164	0.746	0.0709	0.3942	0.04897
WM33	27	5.889	1.251	6.361	5.417	186	0.828	0.0823	0.4333	0.04042
WM86	27	5.889	1.476	6.446	5.332	177	0.751	0.1030	0.4144	0.03879
WM127	26	5.885	1.336	6.398	5.371	170	0.924	0.0927	0.4556	0.04185
WM49	26	5.885	1.143	6.324	5.445	177	1.013	0.0715	0.2857	0.03704
WM78	26	5.885	1.243	6.363	5.407	203	0.957	0.0962	0.3786	0.03641
WM159	25	5.880	1.269	6.377	5.383	167	1.036	0.0644	0.3804	0.04247
WM103	25	5.840	1.491	6.425	5.255	157	0.912	0.0882	0.4857	0.03602
WM41	25	5.840	1.434	6.402	5.278	169	0.828	0.0672	0.4731	0.04664
WM128	27	5.815	1.388	6.338	5.291	174	0.935	0.0789	0.3883	0.03634
WM136	27	5.815	1.075	6.220	5.409	169	1.091	0.0692	0.4135	0.03799
WM51	27	5.815	1.210	6.271	5.358	182	0.806	0.0797	0.3776	0.04121
WM99	27	5.815	0.921	6.162	5.467	178	0.747	0.0776	0.4579	0.04064
WM17	26	5.808	1.833	6.512	5.103	176	0.785	0.0750	0.4632	0.02544
WM134	25	5.800	1.848	6.525	5.075	169	1.068	0.0565	0.3854	0.03643
WM140	25	5.800	1.581	6.420	5.180	168	0.929	0.0906	0.5182	0.04106
WM148	27	5.778	1.368	6.294	5.262	160	1.000	0.0372	0.4174	0.03382
WM23	27	5.778	1.251	6.250	5.306	160	0.765	0.1009	0.4742	0.04342
WM154	25	5.760	1.535	6.362	5.158	176	0.918	0.0735	0.3604	0.03559
WM38	25	5.760	1.832	6.478	5.042	175	0.872	0.0569	0.3678	0.05248
WM68	25	5.760	1.451	6.329	5.191	180	0.874	0.1042	0.4316	0.03924
WM60	29	5.759	1.380	6.261	5.256	167	1.000	0.0875	0.4457	0.03786
WM121	27	5.741	1.289	6.227	5.255	164	0.885	0.1171	0.4455	0.03659
WM142	27	5.741	1.228	6.204	5.278	176	0.924	0.0950	0.4057	0.04222
WM6	27	5.741	1.163	6.180	5.302	150	0.713	0.0840	0.3786	0.04533
WM83	27	5.741	1.509	6.310	5.172	176	0.769	0.0495	0.3429	0.04150

Table A.1 continued from previous page

WM146	26	5.731	1.430	6.280	5.181	159	1.114	0.0562	0.4673	0.03600
WM145	29	5.724	1.730	6.354	5.095	171	0.898	0.0756	0.4078	0.04744
WM52	25	5.720	1.370	6.257	5.183	176	0.808	0.0811	0.3922	0.04255
WM147	27	5.704	1.540	6.284	5.123	194	0.857	0.0904	0.4433	0.03822
WM124	26	5.692	1.463	6.255	5.130	163	0.907	0.0842	0.4059	0.04850
WM139	26	5.692	1.192	6.151	5.234	170	1.051	0.0719	0.4528	0.04035
WM50	26	5.692	1.543	6.286	5.099	179	1.007	0.0926	0.4040	0.04295
WM72	26	5.692	1.543	6.286	5.099	180	1.051	0.1176	0.3524	0.04911
WM87	26	5.692	1.668	6.333	5.051	171	0.849	0.0770	0.3932	0.04178
WM92	26	5.692	1.379	6.222	5.162	184	1.128	0.0744	0.4579	0.05179
WM101	29	5.690	1.312	6.167	5.212	195	1.000	0.0882	0.4685	0.03799
WM84	29	5.690	1.491	6.232	5.147	163	0.798	0.0545	0.4362	0.03422
WM35	27	5.667	1.271	6.146	5.187	160	0.871	0.1009	0.4124	0.04657
WM56	29	5.655	1.233	6.104	5.206	178	0.775	0.0606	0.3939	0.05772
WM160	26	5.654	1.623	6.278	5.030	185	0.904	0.1041	0.4300	0.04932
WM40	26	5.654	1.164	6.101	5.206	164	0.865	0.0744	0.4388	0.03916
WM125	25	5.640	1.411	6.193	5.087	176	1.007	0.1001	0.4040	0.05078
WM82	25	5.640	1.469	6.216	5.064	185	0.873	0.0700	0.4660	0.04664
WM112	27	5.630	1.006	6.009	5.250	186	0.938	0.0938	0.4762	0.04019
WM104	29	5.621	1.399	6.130	5.111	190	0.950	0.1011	0.4423	0.03822
WM158	29	5.621	1.208	6.060	5.181	174	0.891	0.0698	0.3723	0.04888
WM91	26	5.615	1.098	6.038	5.193	174	1.000	0.0785	0.4078	0.04465
WM61	27	5.593	1.647	6.214	4.971	186	0.827	0.0866	0.4388	0.02983
WM62	29	5.586	1.296	6.058	5.114	180	0.718	0.0716	0.4271	0.03979
WM47	26	5.577	1.447	6.133	5.021	174	0.781	0.0943	0.3723	0.05007
WM77	26	5.577	1.604	6.194	4.960	185	0.795	0.0873	0.4190	0.04108
WM113	25	5.560	1.502	6.149	4.971	168	0.924	0.1064	0.5385	0.04958
WM93	25	5.560	1.635	6.201	4.919	192	0.776	0.0717	0.4000	0.03713
WM110	27	5.556	1.423	6.092	5.019	190	0.809	0.0914	0.4796	0.03655
WM44	27	5.556	1.219	6.016	5.096	163	0.757	0.0745	0.3878	0.05098
WM53	29	5.552	1.478	6.090	5.014	179	0.798	0.0943	0.3684	0.03694
WM13	26	5.538	1.655	6.175	4.902	171	0.867	0.0962	0.3832	0.03960
WM45	26	5.538	1.421	6.085	4.992	176	0.881	0.0803	0.4783	0.04697
WM73	26	5.538	1.303	6.039	5.038	189	0.729	0.0708	0.3737	0.05000
WM66	25	5.520	2.002	6.305	4.735	181	0.836	0.0491	0.4040	0.04117
WM119	27	5.519	1.312	6.013	5.024	195	0.846	0.0922	0.4636	0.03527
WM132	29	5.517	1.405	6.028	5.006	177	0.940	0.0962	0.3585	0.03821
WM149	29	5.517	1.299	5.990	5.044	152	0.980	0.0907	0.4474	0.05217
WM120	26	5.500	1.273	5.989	5.011	190	0.881	0.0672	0.3627	0.03785
WM16	26	5.500	1.175	5.952	5.048	170	0.822	0.1049	0.3762	0.03799
WM5	27	5.481	1.369	5.998	4.965	156	0.866	0.0800	0.3535	0.02897
WM102	26	5.462	1.503	6.039	4.884	164	0.980	0.0967	0.3945	0.04337
WM114	26	5.462	1.655	6.098	4.825	162	0.843	0.1006	0.4476	0.03899
WM126	26	5.462	1.140	5.900	5.024	181	1.014	0.0482	0.4111	0.03262
WM89	26	5.462	1.679	6.107	4.816	184	1.232	0.0646	0.3333	0.04121
WM95	29	5.448	1.454	5.977	4.919	188	0.975	0.0903	0.4312	0.03704
WM67	25	5.440	1.261	5.934	4.946	179	0.913	0.0981	0.4516	0.04570

Table A.1 continued from previous page

WM27	26	5.423	1.653	6.059	4.788	166	0.874	0.0704	0.3878	0.04330
WM8	26	5.423	1.724	6.086	4.760	159	0.839	0.0855	0.3960	0.04654
WM123	25	5.400	1.958	6.167	4.633	180	1.067	0.0702	0.4316	0.03179
WM138	25	5.400	2.021	6.192	4.608	192	0.979	0.0797	0.3158	0.03985
WM105	29	5.379	1.347	5.870	4.889	164	1.103	0.0919	0.4257	0.04111
WM55	29	5.379	1.498	5.925	4.834	165	0.767	0.0755	0.4149	0.04701
WM100	27	5.370	1.523	5.945	4.796	193	0.906	0.0800	0.4370	0.03690
WM143	25	5.360	1.777	6.056	4.664	163	0.868	0.0573	0.4369	0.03861
WM155	25	5.360	1.890	6.101	4.619	182	0.777	0.1034	0.4327	0.03796
WM59	25	5.360	1.705	6.028	4.692	188	0.747	0.0447	0.4563	0.04749
WM75	26	5.346	1.979	6.107	4.586	180	1.077	0.1155	0.3010	0.04930
WM107	27	5.333	1.732	5.987	4.680	170	0.914	0.0760	0.4324	0.04534
WM118	27	5.333	1.544	5.916	4.751	172	1.233	0.1094	0.4128	0.04637
WM30	29	5.310	1.491	5.853	4.768	158	0.888	0.1044	0.3673	0.04513
WM96	29	5.310	1.442	5.835	4.786	168	1.079	0.1062	0.4211	0.02968
WM117	26	5.269	1.313	5.774	4.764	186	0.761	0.0891	0.4370	0.04282
WM36	26	5.269	1.801	5.962	4.577	170	0.979	0.1026	0.4330	0.04438
WM37	26	5.269	2.127	6.087	4.452	174	0.792	0.0926	0.4242	0.03704
WM70	29	5.241	1.662	5.846	4.637	177	0.930	0.0315	0.3077	0.04871
WM98	29	5.241	1.504	5.789	4.694	181	0.862	0.1021	0.3673	0.03800
WM9	25	5.240	1.786	5.940	4.540	167	0.767	0.0809	0.4536	0.03824
WM137	26	5.231	1.883	5.954	4.507	176	1.106	0.0448	0.4086	0.03689
WM34	26	5.231	2.233	6.089	4.373	190	0.709	0.0912	0.4286	0.04416
WM108	29	5.207	1.567	5.777	4.637	160	0.982	0.0813	0.4054	0.03651
WM151	29	5.207	1.521	5.760	4.653	162	0.886	0.0760	0.4190	0.05617
WM19	29	5.207	1.398	5.716	4.698	163	0.859	0.0919	0.3168	0.05014
WM7	29	5.207	1.656	5.810	4.604	164	0.853	0.0823	0.3402	0.05128
WM115	26	5.192	1.266	5.679	4.706	170	0.905	0.0713	0.5957	0.04938
WM48	26	5.192	1.674	5.836	4.549	181	0.786	0.1038	0.4340	0.03974
WM57	26	5.192	1.898	5.922	4.463	180	0.899	0.0752	0.3837	0.03900
WM79	26	5.192	1.357	5.714	4.671	165	0.875	0.0824	0.4646	0.04121
WM116	29	5.172	1.583	5.748	4.596	160	0.974	0.0875	0.4907	0.04556
WM39	26	5.154	1.804	5.847	4.460	166	1.192	0.0864	0.4608	0.04319
WM152	29	5.138	1.642	5.735	4.540	162	1.024	0.0649	0.3981	0.04447
WM157	26	5.115	1.275	5.606	4.625	154	1.011	0.0775	0.4091	0.04193
WM111	27	5.111	1.826	5.800	4.422	171	1.044	0.0938	0.4262	0.03751
WM18	27	5.074	1.685	5.710	4.438	164	0.882	0.0864	0.4400	0.04654
WM122	25	5.040	1.594	5.665	4.415	177	0.964	0.1186	0.4273	0.04600
WM14	25	5.040	2.051	5.844	4.236	171	0.821	0.0863	0.3402	0.03268
WM22	29	5.034	1.614	5.622	4.447	159	0.755	0.0711	0.4301	0.04881
WM24	27	5.000	1.776	5.670	4.330	154	0.744	0.0945	0.4636	0.04937
WM65	29	5.000	1.414	5.515	4.485	182	0.881	0.1020	0.4600	0.03268
WM1	26	4.962	1.777	5.645	4.278	164	0.667	0.0864	0.3396	0.05124
WM88	26	4.962	1.509	5.542	4.381	177	1.153	0.1034	0.4300	0.04058
WM32	29	4.931	1.438	5.454	4.408	189	0.827	0.1127	0.3736	0.04729
WM63	29	4.931	1.668	5.538	4.324	180	1.000	0.0865	0.3714	0.05503
WM80	27	4.926	1.685	5.562	4.290	186	1.216	0.0964	0.2626	0.04227

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WM31	26	4.923	1.998	5.691	4.155	184	0.900	0.1202	0.4105	0.04348
WM106	29	4.897	1.589	5.475	4.318	176	0.897	0.0605	0.4646	0.03915
WM135	26	4.885	1.862	5.600	4.169	177	1.092	0.0720	0.4000	0.03785
WM29	26	4.885	1.818	5.584	4.186	165	0.787	0.1159	0.5213	0.04721
WM97	29	4.862	1.642	5.460	4.265	192	0.796	0.1023	0.4322	0.04318
WM43	29	4.828	1.983	5.549	4.106	175	0.661	0.0973	0.4545	0.03372
WM90	26	4.808	1.789	5.495	4.120	170	0.751	0.0566	0.4574	0.04118
WM54	25	4.640	2.158	5.486	3.794	178	0.737	0.0814	0.3535	0.04429
WM2	27	4.481	1.718	5.130	3.833	151	0.868	0.1098	0.4200	0.05827
WM64	25	4.080	1.412	4.633	3.527	181	0.986	0.0955	0.4222	0.05825
WM85	26	4.077	1.695	4.729	3.425	165	0.968	0.1129	0.4184	0.04683
WM69	29	3.897	1.819	4.559	3.234	162	0.814	0.0886	0.4020	0.05369