DO MEMORIES FOR SAME- AND OTHER-RACE FACES CHANGE AFTER A CONSOLIDATION PERIOD?

By

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ABSTRACT

The other-race effect is a well-documented phenomenon, in which participants show more accurate face memory for members of their own race compared with face memory for members of other races. Although current theories aimed at explaining the ORE take quite different approaches, most explanations assume that differences in memory for faces of different races arise from processes that occur during encoding. The current study was designed to examine if differences in time-dependent memory consolidation affect the recognition of same- and other-race face memories. Hispanic and Caucasian participants studied same- and other-race faces and took initial recognition tests for same-and other-race faces. They returned two days later for a final recognition test. In the Hispanic group, memory for other-race faces improved more than memory for same-race faces. This difference was not present in the Caucasian group. These results suggest that consolidation can influence how face memories are consolidated in Hispanic participants.

I. INTRODUCTION

The human face is a uniquely important stimulus that conveys a variety of critical social and emotional information. Therefore, humans have developed an expertise in processing faces. However, not all faces are processed equally as well and there are several biases that exist, such as greater recognition accuracy for faces belonging to the perceiver's same age group (Anastasi & Rhodes, 2005) and gender (Wright & Sladden, 2003). Another bias, the other-race effect (ORE), is a well-documented phenomenon (Meissner & Brigham, 2001) in which participants show more accurate face memory for members of their own race compared with face memory for members of other races (Young, Hugenberg, Bernstein, & Sacco, 2012). Interest in this topic among researchers, as well as its relevance in society for instances such as eyewitness identification (Chance & Goldstein, 1996), has led to the development of several theoretical explanations in an attempt to demystify this phenomenon. This thesis will explore how memory processes that act on memory representations after initial learning may influence the ORE.

There are three primary phases of memory; encoding, consolidation, and retrieval. The initial learning event during which information is input into memory is referred to as encoding. The recently encoded memory then undergoes a process of consolidation, as it is transformed over time from a fragile to a more enduring state. Retrieval describes the process of searching for and recalling this stored memory. Theoretically, it is possible that the ORE could arise from processes occurring during the encoding, consolidation, or retrieval of face memories, although most current theories have exclusively focused on processes occurring at encoding (Young et al., 2012). The two most prominent theories aimed at explaining the ORE through processes that occur at encoding can be broadly categorized as *perceptual expertise* and *social cognitive* models. These theories have been cultivated independently with relatively little exchange of concepts until the recent development of hybrid models, which combine aspects of each (Young et al., 2012).

Perceptual Expertise Models

The core assumption of perceptual expertise models is that racial segregation, either formally or informally, leads to a lack of social contact between races, resulting in more exposure to one's own race (Young et al, 2012). This leads to greater expertise for identifying faces belonging to one's own race compared with faces of other races. Importantly, the lack of social exposure to other races results in relatively inefficient perceptual processing of other-race faces in comparison to the perceptual processing of same-race faces (Tanaka, Kiefer, & Bukach, 2004). There is even some evidence to suggest that this bias appears very early in infant development. Using measures of gaze duration as an index of preference (i.e., longer gaze times reflect a greater preference), Kelly, Quinn, Slater, Lee, Ge, and Pascalis (2007) investigated the emergence of the ORE in infancy by comparing facial gaze preferences of Caucasian infants born in the United Kingdom aged 3, 6, and 9 months for different races (Caucasian, African, Middle Eastern, and Chinese). The authors found that the 3-month infants did not appear to show gaze preferences for faces of different races. However, 6-month infants showed a preference for Caucasian and Chinese faces, while 9-month infants had a preference only for

Caucasian faces. This evidence of perceptual narrowing suggests that early environmental input can influence the development of the ORE.

Although it appears that perceptual narrowing and consequently the ORE is established early in human development, there is some evidence that suggests that the mechanisms underlying this bias remain malleable even into adulthood. Evidence that social contact and experience with other races can reverse the ORE comes from a study by Sangrigoli, Pallier, Argenti, Ventureyra, and de Schonen (2005). The authors examined face recognition of adults born in Korea who were adopted as children by French parents. These Korean-born adult participants had a mean age of arrival in France of 6 years. This is well after the emergence of the ORE, which is around 9 months (Kelly et al., 2007). These participants were tested on face recognition and compared against adult French natives, and adult Korean natives who had been residing in France for an average of 4.5 years. The Korean adoptees performed similarly to the French natives in a recognition test of Caucasian and Asian faces in that both groups exhibited superior recognition for Caucasian faces compared to Asian faces. These findings suggest that the underlying mechanisms responsible for the ORE remain malleable, such that immersive social contact and experience with other races can eliminate the recognition bias.

The results from Sangrigoli et al. (2005) exemplify a primary prediction of perceptual expertise models. That is, as members of one race increase contact with members of another race, their ability to efficiently identify faces of the other race increases. In other words, more contact leads to more efficient processing, and consequently better recognition abilities. Hancock and Rhodes (2008) found that the magnitude of the ORE could be predicted based on self-reported measures of social contact with other races. The authors found an inverse relationship between measures of social contact with another race and the magnitude of the ORE. These results corroborate the notion that the ORE is mediated by social contact, as predicted by perceptual expertise models.

Perceptual expertise models also suggest there are two qualitatively different processing styles used to evaluate same- and other-race faces. Same-race faces are processed in a holistic or *configural* fashion, while other-race faces are evaluated in a *feature-based* or fragmented manner (Michel, Rossion, Han, Chung, & Caldera, 2006). When a perceiver encodes a face in a configural manner, the spatial locations of all prominent features (eyes, nose, etc.) are processed in relation to one another to create a holistic representation (Maurer, Le Grand, & Mondloch, 2002). Conversely, when faces are encoded in a feature-based manner, each feature is processed separately, and the spatial relationships between facial features are not taken into account (Michel et al., 2006).

Theoretical evidence for the use of these different processing strategies during same- and other-race face encoding comes primarily from studies employing composite and inversion paradigms. Composite faces are typically made from dividing a face horizontally at the middle of the nose and splicing the top half of that original face with the bottom half of another face of the same race and gender. In Michel et al. (2006), on each trial, Caucasian and Asian participants were shown a target face followed by a composite face, which was either their same race or the other race. Importantly, the target and composite faces were always the same race and gender. They were told explicitly to pay attention to the top half of all the faces they would be shown throughout the experiment. Each composite face was made from either the top half of the preceding target face, or the top half of a face that was not the preceding target face. Additionally, the composite faces were also shown either aligned or misaligned, where the top and bottom halves were offset from one another. The aligned/misaligned manipulation was intended to test whether the faces were processed holistically, such that when composite faces are aligned, they are more likely to be processed holistically. The participants' task was to determine if the top half of the composite face matched the top half of the preceding target face. The authors found a greater effect for same-race faces, such that participants identified the misaligned version of the same-race composites more accurately than the aligned versions. The authors explain that this pattern of results is due to greater recognition interference from the bottom half of the aligned faces in the same-race trials compared to the other-race trials. This suggests that same-race faces are more likely to be processed holistically compared to other-race faces.

In the inversion paradigm, faces are inverted during an encoding session to disrupt information about the spatial relationships between facial features normally extracted from naturally positioned faces (Young et al., 2012). Therefore, interrupting the configural encoding of same-race faces by inverting them should disrupt configural processing to a greater extent than feature-based processing, and lead to similar subsequent recognition ability for same-race and other-race faces, which has been observed (Goffaux & Rossion, 2006).

The underlying logic of configural and feature-based processing explanations of the ORE is that disproportionate social contact with same- and other-race faces leads to qualitatively different encoding strategies. Specifically, increased social contact with same-race faces leads to configural encoding where all facial features are assessed in a relational manner. Conversely, a lack of social contact with other-race faces leads to processing other-race faces in a fragmented manner where each feature is assessed in isolation.

A different perspective attempting to explain the effects of perceptual expertise on the ORE comes from representational models. These models postulate that differences in how same-race and other-race faces are represented in memory can explain the memory advantage for same-race faces compared with other-race faces. Specifically, Valentine (1991, 2001) has introduced the face-space hypothesis, which suggests that all faces are represented across a multidimensional face space. The idea is that faces are complex structures with several identifying features such as the eyes, nose, ears, mouth, hair, the relative distance between these features, dimensions, adiposity, and skin tone. Therefore, face space is an individually tailored multidimensional space where each facial feature is contained or represented within a single dimension (Abudarham & Yovel, 2016). Additionally, individual faces are assumed to occupy a single point in face space. The distribution of faces in this space is largely dependent upon perceived similarities whereby the distance between faces or points in this space can be considered as a measure of similarity between them. For example, two faces with similar features would be closer together than two faces with dissimilar features.

Valentine (2001) and Valentine and Endo (1992) propose that same-race faces are perceived as more distinctive than other-race faces, and are consequently more widely distributed across this space. Conversely, other-race faces are clustered more closely. The perceived similarity across facial features of other-race faces leads to a denser clustering in face space, while same-race faces have more distinctive facial features leading to a wider spatial distribution. The dense grouping of other-race face representations could account for the relatively high rate of false positive responses (incorrectly identifying a novel face as old) for other-race faces compared with same-race faces in ORE experiments (Caldera & Abdi, 2006).

Caldara and Abdi (2006) explored the influence that face exposure has on the organization of face space. Using neural network models guided by autoassociative memory simulation algorithms, two algorithms were trained separately with 158 images split evenly between male and female. One algorithm was trained with only Caucasian faces, while the other was trained exclusively with Asian faces. Each algorithm was then evaluated on recognition accuracy of faces from the race for which it did not receive training. Within the algorithms, each face was represented as a point with specific coordinates in face space. Using principal component analyses, the distance between points were measured in order to quantify the relative physical similarity between face memory representations. This produced 3D maps by plotting the coordinates of each face representation in relation to its neighbors as well as their distance from the average of the face representations. The results revealed that the distances between each of the same-race faces were greater and that same-race faces had a wider distribution across this space compared with other-race faces, supporting the hypothetical spatial characteristics of face space described by Valentine (1991, 2001).

Several insights into the ORE have been derived from perceptual expertise models, such as the differences in how faces of different races are encoded and represented in memory. However, these models do not account for the extent to which the ORE is influenced by factors and memory processes that occur after encoding. Social cognitive models attempt to address how facial memory for other races is influenced by social factors (Young et al., 2012), such as the tendency to categorize in- and out-group members.

Social Cognitive Models

Social cognitive models provide an alternative perspective to explain the ORE. Proponents of these models argue that in- and out-group status, which can lead to cognitive disregard of out-group members, change our cognition in a way that affects how we categorize or individuate faces, which consequently influences the way those faces are encoded into memory (Young et al., 2012).

The tendency to broadly categorize out-group members while conversely individuating in-group members has been demonstrated across racial dimensions (Brewer, Weber, & Carini, 1995; Hugenberg et al., 2010), socioeconomic status (Shriver et al., 2008), and religious affiliation (Rule, Garrett, & Ambady, 2010). In the context of the ORE, cognitively labeling another race as an out-group could have detrimental effects on face encoding. A prominent concept known as cognitive disregard suggests that out-group members have less social relevance than in-group members, and as a result less cognitive resources are used during the encoding of faces of out-group members (Young et al., 2012).

Evidence supporting cognitive disregard as an explanation for the ORE comes from a study conducted by Goldinger, He, and Papesh (2009), where the authors demonstrated that both Caucasian and Asian participants spent more time viewing the eyes and hair of members of their same race, while attending to the mouth and nose of members of the other race. This implies a qualitatively different approach in the evaluation of facial features for same- and other-race faces. Additionally, participants showed less pupil dilation when viewing other-race faces compared with same-race faces. This measure suggests that cognitive disregard occurred during the viewing of other-race faces, as pupil dilatation is considered a reliable measure of cognitive effort (Sibley, Coyne, & Baldwin, 2011). These results suggest that cognitive disregard can influence how faces are encoded, which ultimately influences recognition memory for those faces.

The tendency to categorize out-group members and individuate in-group members is also consistent with the feature selection model (Young et al., 2012). This model suggests that socially guided motives to either individuate in-group members or categorize out-group members influences which facial features are encoded. As a result, racial characteristics like skin tone are given preference over features that could be used to distinguish individual out-group members. For example, racial features are preferentially processed over individuating features, which leads to faster categorization of other-race faces compared to same-race faces on the dimension of race (Ge et al., 2009; Levin, 1996, 2000). Furthermore, visual search time for an other-race face among same-race faces is related to the magnitude of the ORE. Levin (2000) found that participants who exhibited a deficit in recognizing other-race faces had faster detection times when searching for an other-race face among same-race-faces. In other words, as the magnitude of the ORE increases, visual search times for other-race faces among same-race faces decreases.

Collectively, this evidence demonstrates that social factors can impact how same- and other-race faces are encoded. However, like the perceptual expertise accounts, social cognitive accounts are also subject to theoretical challenges. Zhao and Bentin (2008) found that race is not a significant factor for the categorization of same- and other-race faces across non-racial dimensions, specifically age and gender. Their study revealed that reaction times to categorize same- and other-race faces based on age and gender was not mediated by the race of the target face. Despite this, social cognitive accounts have highlighted how categorization and individuation processes at encoding can influence the ORE.

Memory Consolidation

Whereas both the perceptual expertise and social cognitive models have been used to address various phenomenological aspects of the ORE, they do not provide an exhaustive account of this effect (Young et al., 2012). For example, one factor that has not been previously considered by these models is that memory processes that take place after encoding may contribute to the ORE. Whereas both perceptual expertise and social cognitive models posit that the ORE arises due to processes that take place at the time of encoding, it is possible that memory consolidation processes may also differentially influence memory for same- and other-race faces.

The notion of memory consolidation was initially proposed over 100 years ago (Muller & Pilzecker, 1900), and has more recently been identified as a complex multi-stage process by which memories are established and transformed over time. Several studies have demonstrated that consolidation optimally occurs during sleep (Stickgold, 2005; Walker & Stickgold, 2004), but may also occur to a lesser extent during waking (Peigneux et al., 2006). During consolidation, individual memories are transferred from a fragile to a more enduring state (Stickgold, 2005). This process is thought to involve the repeated re-activation of recently learned memories as they are transferred from temporary storage sites in the hippocampus, and integrated with existing knowledge across the cortex for permanent storage (Frankland & Bontempi, 2005). Although the exact time course of consolidation is unclear and likely depends on several factors, it is thought that this process could take several months or even several years to be fully complete (McGaugh, 2000).

Although not previously considered, it is possible that the extent to which same- and other-races faces are consolidated may differ. An important aspect of consolidation is that it appears to be discriminatory, such that not all recently encoded information is consolidated equally. Rather, salient memories and memories with direct relevance for future goals appear to be strengthened more so than others (Stickgold & Walker, 2013). It is thought that the “selective” nature of consolidation may have evolved as an adaptively advantageous memory mechanism, such that all recently encoded experiences are evaluated, and memories that are useful or relevant for achieving future goals may be strengthened to a greater extent than other recently encoded information (e.g., Cartwright, 2004; Winson, 2004). Supporting this view, memory for emotionally imbued items typically improves more so than memory for neutral information after a consolidation period (Atienza & Cantero, 2008; McGaugh, 2004; Paré, Collins, & Pelletier, 2002), indicating that stimulus salience can influence consolidation. Furthermore, Wilhelm, Diekelmann, Molzow, Ayoub, Mölle, & Born (2011) demonstrated that recall of word-pairs after a 9-hour sleep interval improved to a greater extent for participants who were told that their memories would be tested in the future compared to participants who did not know their memories would be tested. This and other studies have convincingly demonstrated that relevance of memories for the future can influence the extent of consolidation (Murayama & Kuhbandner, 2011; Oudiette & Paller, 2013; Saletin, Goldstein, & Walker, 2011).

The notion that information relevant for achieving future goals is consolidated more so than irrelevant information could have interesting implications if extended to same-and other-race face memory. Membership in close social groups is often mediated by race (Kao, & Joyner, 2004; McPherson, Smith-Lovin, & Cook, 2001), which implies that same-race faces may be more socially relevant than other-race faces. Therefore, it may be possible that same-race faces are considered to be more relevant for future social goals than other-race faces, and are therefore consolidated to a greater extent.

Another aspect of memory consolidation that could differentially influence same- versus other-race face memories is the process of item integration that is thought to occur during consolidation, wherein commonalities across recently learned items are identified, resulting in new knowledge about underlying themes or the "gist" of this recently learned information (Walker & Stickgold, 2013). Evidence of enhanced gist knowledge is seen in studies using a false memory task in which subjects are exposed to a list of words that share a common theme. For example, field, end zone, pass, catch, run, stadium, touchdown, etc., are all words associated with football. After sleep, compared to an equivalent time spent awake, subjects are more likely to indicate that they had previously seen the word football. Often, as in Payne et al., (2009), false memories for the theme of a studied word list (e.g., football) are "recalled" at a higher rate than memories for the words that actually appeared on the list. This suggests that knowledge of commonalities between related items are strengthened during sleep, and at times more so than memories for individual items (Payne et al., 2009).

Purpose of the Current Study

The current study was designed to examine whether the consolidation of same- and other-race face memories influences subsequent face recognition accuracy. Although this has not been directly tested previously, some evidence does suggest that consolidation can differentially impact prejudice formation associated with racial in-group versus out-group members. In a study by Enge, Lupo, and Zarate (2015), subjects were exposed to positive and negative trait information paired with images of in- and out-group members. Participants then made lexical decisions about target trait words and non-words paired with old and new images after an overnight consolidation period, or a short 2-6 hour delay. As expected, participants responded faster for negative traits paired with out-group members and positive traits paired with in-group members, and this difference was greater after the overnight delay compared to the short delay. The authors suggest memory consolidation facilitated gist level extraction of traits associated with both groups, and participants generalized this to all members such that positive traits were associated with in-group members and negative traits with out-group members.

In the present experiment, Hispanic and Caucasian participants studied same- and other-race faces immediately followed by recognition tests to provide a baseline measure of recognition accuracy for same- and other-race faces. After a two-day consolidation period, participants returned to the lab and completed a final recognition task to determine the extent of change in same- versus other-race face memory. If the faces of one's own race are preferentially consolidated compared to other-race faces, it was expected that participants' recognition accuracy for same-race faces would improve to a greater extent than accuracy for other-race faces after the two-day consolidation period.

II. METHOD

The current study was approved by the Texas State University Institutional Review Board.

Participants

Caucasian and Hispanic participants were undergraduate students recruited from the Texas State University Psychology Department participant pool in exchange for course credit. A total of 38 participants (19 Hispanic, 19 Caucasian) were initially recruited for this experiment. However, 1 Caucasian and 3 Hispanic participants were excluded from analyses because of errors in data collection. The data from 34 participants (Hispanic: male = 5, female = 11; Caucasian: male = 5, female = 13) were included in all analyses. All participants self-identified their ethnicity.

Materials

The Karolinska sleep log (Akerstedt et al., 1994) was administered to assess participant sleep quantity and quality for the night before session 1, and for the two intervening nights of sleep before session 2. The Karolinska sleep log is comprised of 6 questions regarding quantity of sleep (duration of sleep, number of awakenings, etc.), and 7 questions that assess subjective sleep quality on a five-point scale (e.g., How soundly did you sleep?, How much did you dream?, etc.).

A set of 75 Hispanic faces (38 female and 37 male), and 75 Caucasian faces (38 female and 37 male) taken from a high school yearbook were each divided into 3 sets of 25 faces (2 sets=12 male, 13 female; 1 set=13 male, 12 female). One set of faces was used as old (studied during session 1), one as new during test 1, and the third set was used as new during test 2. The assignment of each of the three sets of faces to these three conditions was counterbalanced across participants. All face images were in color, and had dimensions of 259 x 324 pixels.

Procedure

The experiment took place over the course of two sessions, separated by 48 hours. During the first session, after giving informed written consent and completing the Karolinska sleep log with regard to the night of sleep prior to session 1, half of the participants studied and a took a recognition test for same-race faces, and then studied and took a recognition test for other-race faces. For the other half of participants, the study/test procedure occurred first for other-race faces and then for same-race faces. For the study phase of each test, participants were seated in front of a computer and presented with 25 faces one at a time for 4 s each, preceded by a fixation cross appearing for 500 ms. While each face was on the screen, participants were instructed to press the "M" key if the face was male and the "F" key if the face was female, to ensure participants paid attention to each face. Next, participants completed a distractor task to clear their short-term memories for the faces, wherein they completed one page of basic math problems. Participants then took a recognition test, including the 25 old faces presented in the study phase and 25 new faces, randomly intermixed. During each of the 50 test trials, a fixation cross appeared in the center of the screen for 500 ms followed immediately by a face for 2 s. The participants were then prompted to input their response. The prompt remained on screen until a decision was entered. Participants indicated their decision by pressing the “1” key if they thought the face was old and the “2” key if they thought the face was new.

Participants returned to the lab 48 hours after the first experimental session. When participants arrived for the second session, they first filled out two Karolinska sleep logs, one for each of the two intervening nights of sleep. Immediately following the completion of the sleep logs, participants completed a final recognition test including 50 faces from each race (25 old, 25 new) randomly intermixed. During each of the 100 test trials, a fixation cross was presented in the center of the screen for 500 ms followed immediately by a face for 2 s. Participants were then prompted to indicate their decision, and the prompt remained on screen until a decision was entered. The participants indicated their decision by pressing the “1” key if they thought the face was old and the “2” key if they thought the face was new.

Attractiveness ratings

Since previous research has found that more attractive faces are remembered better than less attractive faces (Marzi & Viggiano, 2010; Wiese, Altmann, & Schweinberger, 2014), the faces used as stimuli in the main experiment were rated on attractiveness by 90 additional participants to ensure that memory differences observed in the main experiment were not influenced by differences in attractiveness between the Caucasian and Hispanic faces. The raters consisted of 3 Asian Americans, 7 African Americans, 24 Hispanics, and 56 Caucasians with a mean age of 24. For the ratings, faces were printed in color on 8.5 x 11 inch pages (12 faces per page) and participants rated the attractiveness of each face on a scale from 1-4 (1=not attractive, 4=very attractive) by writing the scale value next to each face.

Each participant rated 50 faces (25 Caucasian, 25 Hispanic) of the 150 total faces used in the experiment. The specific faces seen by each rater were counterbalanced across participants, such that each of the 150 faces was rated by 30 participants.

III. RESULTS

Attractiveness Ratings

The average attractiveness rating for each face was computed and the average attractiveness ratings for Hispanic faces were compared with the average attractiveness ratings for Caucasian faces using an independent samples *t*-test. Average attractiveness ratings are reported by face race and face gender in Table 1. The result of the *t*-test indicated no significant difference in the level of attractiveness between Caucasian and Hispanic faces, $t(148) = .072$, $p = .94$. Additionally, attractiveness ratings were compared by gender across races. There were no significant differences between Hispanic and Caucasian female faces, $t(74) = 1.08$, $p = .28$, or Hispanic and Caucasian male faces, $t(72) = -1.3062$, $p = .20$.

Table 1. Average attractiveness ratings for faces used in the experiment. Standard deviation in parentheses.

	All Faces	Male Faces	Female Faces
Caucasian Faces	2.27 (0.47)	2.10 (0.46)	2.43 (0.42)
Hispanic Faces	2.26 (0.58)	1.96 (0.44)	2.55 (0.55)

Sleep Measures

Average responses on the Karolinska sleep log for the night before session 1 and for the two intervening nights between sessions 1 and 2 are reported in Table 2. Data from the night before session 1 were examined to ensure that both Hispanic and Caucasian participants had an average 7 – 9 hour night of sleep (Hirshkowitz, Whiton, Albert, Alessi, Bruni, DonCarlos, Neubauer, 2015) prior to encoding faces, as poor sleep has been shown to disrupt encoding (Yoo et al., 2007). A *t*-test was used to examine sleep quantity (total hours of sleep) between the groups for the night prior to the encoding session. The *t*-test revealed no significant difference in the average amount of sleep before the first session $t(32) = -0.344$, $p > .73$ (Hispanic mean = 7.11 sd = 0.91, Caucasian mean = 6.96 sd = 1.53). Additionally, *t*-tests were conducted on responses to the other questions on the Karolinska sleep log to determine if any other measures of sleep quality and quantity differed between Hispanic and Caucasian participants. There were no significant differences between groups on any question (all p values $> .19$), with one exception. Hispanic participants reported that they slept more soundly than Caucasian participants, $t(32) = -2.196$, $p < .05$.

Memory consolidation is thought to optimally occur during sleep (Stickgold, 2005; Walker & Stickgold, 2004). Therefore it was critical to ensure that there were no substantial differences in sleep quality or quantity between groups for the two intervening nights of sleep between session 1 and session 2. To analyze the sleep data for the intervening nights, measures of sleep quality and quantity were calculated. To quantify sleep quality, responses from questions 7-13 of the Karolinska sleep log were summed separately for each night. These totals were then averaged across the two intervening nights, as in Westerberg et al. (2015). Sleep quality did not differ significantly across groups, $t(32) = 0.989$, $p > 0.33$. For sleep quantity, answers from question 3 from the Karolinska sleep log (How long did you sleep?) were summed across the two intervening nights between sessions 1 and 2 to obtain a measure of total sleep time. There were no significant differences in sleep quantity between the groups, $t(32) = 0.443$, $p > 0.66$.

Table 2. Mean responses for each of the Karolinska sleep logs. Questions for 3 nights (Night 1 = night before session 1, Night 2 = night of encoding session, Night 3 = night before session 2). Standard deviations in parentheses. Standard deviations for questions 1, 2, and 3 (hr.min).

Questions	Night 1 Caucasian	Night 1 Hispanic	Night 2 Caucasian	Night 2 Hispanic	Night 3 Caucasian	Night 3 Hispanic
1) At what time did you got to bed and turn the light off last night?	1:39 AM (.46)	12:29 AM (.42)	1:19 AM (.43)	1:55 AM (.47)	1:32 AM (.07)	11:33 PM (.03)
2) At what time did you arise this morning?	8:35 AM (.13)	7:40 AM (.06)	8:09 AM (.43)	9:13 AM (.45)	8:18 AM (.09)	7:40 AM (.05)
3) How long did you sleep? (Hours)	6.96 (1.53)	7.11 (0.91)	7.28 (3.20)	7.58 (1.15)	7.36 (2.17)	7.67 (3.00)
4) How long did you take you fall asleep? (Minutes)	26.39 (17.89)	27.81 (29.27)	20.94 (18.66)	22.19 (17.22)	25.67 (19.00)	24.06 (21.28)
5) How many awakenings did you have last night?	1.00 (1.53)	0.88 (0.81)	1.12 (1.22)	1.00 (1.32)	0.67 (0.77)	3.38 (7.23)
6) How many total minutes were you awake after falling asleep last night? (Minutes)	11.41 (18.12)	8.07 (11.07)	8.65 (10.36)	9.47 (14.09)	10.89 (16.25)	14.19 (18.72)
7) How did you sleep? (1-very poorly, 5-very well)	3.67 (0.69)	4.00 (0.82)	3.76 (0.75)	4.13 (0.96)	3.72 (1.18)	3.07 (1.39)
8) Did you feel refreshed after you arose this morning? (1-non at all, 5-completely)	3.28 (0.83)	3.69 (0.95)	3.47 (1.07)	3.44 (1.15)	3.22 (1.17)	2.69 (1.20)
9) Did you sleep soundly? (1-very restless, 5-very soundly)	3.67 (0.84)	4.31 (0.87)	3.59 (1.06)	3.81 (1.33)	3.56 (1.15)	3.44 (1.15)
10) Did you sleep throughout the time allotted for sleep? (1-woke up much too early, 5-slept thru the night)	4.00 (1.28)	4.31 (0.87)	3.88 (1.05)	3.81 (1.33)	3.72 (1.18)	3.31 (1.35)
11) How easy was it for you to wake up? (1-very easy, 5 -very difficult)	2.89 (0.96)	2.38 (1.26)	2.94 (1.25)	2.25 (1.13)	3.44 (1.29)	3.31 (1.25)
12) How easy was it for you to fall asleep? (1-very easy, 5-very difficult)	2.17 (1.10)	2.38 (1.20)	2.65 (1.11)	2.88 (1.31)	2.61 (1.24)	2.94 (1.06)
13) How much did you dream last night?	2.28 (1.07)	2.63 (1.50)	2.41 (1.00)	2.56 (1.50)	1.94 (1.11)	2.38 (1.41)

Memory

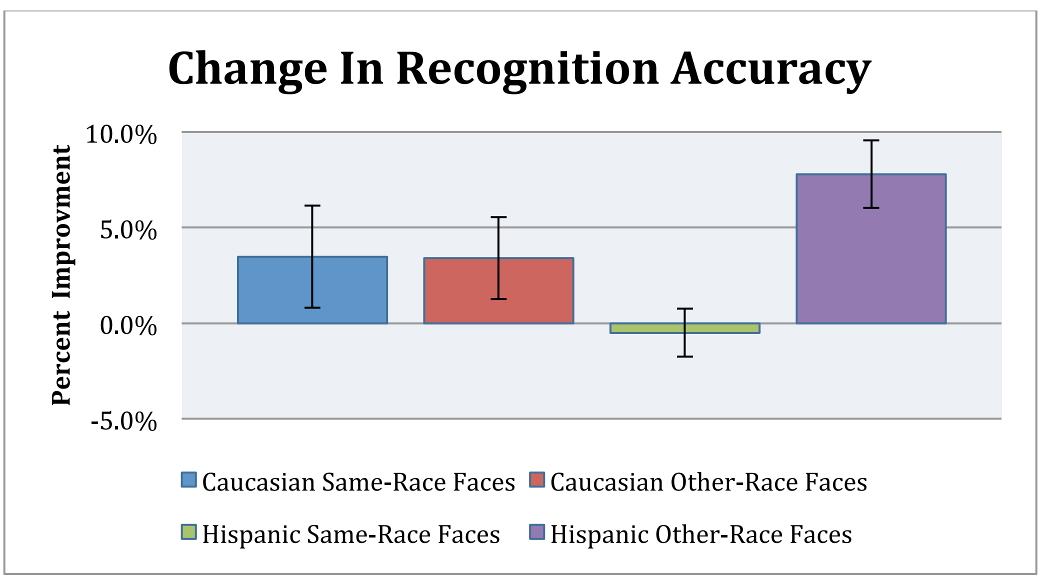
Recognition accuracy (percent correct) was computed for same-race faces and for other-race faces for both experimental sessions (1 and 2) for all participants. Percent correct scores (Table 3) were then submitted to a mixed model 2x2x2 ANOVA, with session (1, 2) and face type (same-race, other-race) as within-subjects variables and participant race (Caucasian, Hispanic) as a between-subjects variable. The analysis revealed a main effect of session, such that memory for all faces was better during session 2 compared with session 1, F(1, 32) = 9.407, $p < .01$, $\eta_p^2 = .23$. Additionally, a session x face type interaction was also present, F(1, 32) = 4.819, $p < .05$, $\eta_p^2 = .13$. However, these effects were modulated by a three-way session x face type x participant race interaction, $F(1, 32)= 8.327$, $p < .01$, $\eta_p^2 = .21$. To determine whether improvements in recognition accuracy from session 1 to session 2 were present for all conditions, paired *t*-tests were conducted comparing session 1 percent correct with session 2 percent correct for same-race faces and for other-race faces for Caucasians and for Hispanics. The results indicated a significant increase in memory for other-race faces for Hispanics, $t(15)= -4.15$, $p> .001$, and a marginally significant increase in other-race face memory for Caucasians, $t(17)= -2.09$, $p= .052$. However, there was not a significant improvement for same-race faces for Caucasians, $t(17)= -1.16$, $p> .26$, or for Hispanics, $t(15)= 0.37$, $p> .71$. To further explore the nature of this interaction, improvement scores were calculated for each participant by subtracting percent correct on the session 1 test from percent correct on the session 2 test for each face type (same-race, other-race). Subsequent paired *t*-

tests revealed that memory improvement was greater for other-race faces than for same-race faces for Hispanic participants, $t(15) = -4.83$, $p < .001$, but not for Caucasian participants, $t(17) = -.42$, $p > .68$ (see Figure 1).

Table 3. Mean percent correct values. Standard deviations in parentheses.

		Session 1	Session 2
Caucasian Participants	Same-Race Faces	78.3 (7.4)	81.3 (9.0)
	Other-Race Faces	75.0 (7.7)	79.1 (7.7)
Hispanic Participants	Same-Race Faces	80.1 (7.4)	79.6 (4.5)
	Other-Race Faces	74.7 (9.0)	82.5 (10.2)

Figure 1. Change in recognition accuracy from session 1 to session 2.



Sleep and Memory

Responses gathered from the Karolinska sleep log for the night preceding session 1 were used to examine potential relationships with memory performance during session 1. As same- and other-race percent correct measures were used as in multiple comparisons, a more stringent alpha level of .01 was used for these analyses. For Caucasian participants, no significant correlations between same-race face memory and any of the sleep measures were observed (All p values > .07), nor were any correlations between other-race face memory and any of the sleep measures present (All p values > .06). No significant relationships were found for Hispanic participants between same-race face memory and sleep measures (all p values > .02), or between other-race face memory and sleep measures (all p values > .05).

To determine whether measures of sleep quantity and/or quality from the intervening nights between sessions 1 and 2 predicted memory improvement for same- or other-race faces, memory improvement scores for each face-race type were correlated with measures of sleep quantity and quality, and again, a more stringent threshold of p<.01 was used to correct for multiple comparisons. For sleep quantity, answers from question 3 from the Karolinska sleep log (How long did you sleep?) were summed across the two intervening nights between sessions 1 and 2 to obtain a measure of total sleep time. For Hispanic participants, sleep quantity was not related to change in same-race memory [$r(15)$= -.098, p > .7] or change in other-race memory [$r(15)$= -.177, p > .5]. Similarly, for Caucasian participants, no significant correlations were observed between sleep quantity and change in same-race memory [$r(17) = .008$, $p > .9$], or change in other-race memory [$r(17) = .002$, $p > .9$]. To quantify sleep quality, responses from questions 7-13 of the Karolinska sleep log were summed separately for each night. These totals were then averaged across the two intervening nights, as in Westerberg et al. (2015). Sleep quality for Hispanic participants was not related to change in same-race memory [$r(15) = .129$, $p > .6$] or change in other-race memory [$r(15) = .162$, $p > .5$]. Likewise, for Caucasian participants, sleep quality was not significantly correlated with change in same-race memory [$r(17) = .019$, $p > .9$] or change in other-race memory [$r(17) = .157$, $p > .5$].

IV. DISCUSSION

Memory for same-race faces is typically better than memory for other-race faces; a finding that is usually attributed to factors that affect how same- versus other-race faces are encoded (Goffaux & Rossion, 2006; Goldinger et al., 2009; Maurer et al., 2002; Michel et al., 2006). The current study was designed to examine if the extent to which same- versus other-race faces are consolidated influences the ORE. It was predicted that same-race faces would be preferentially consolidated over other-race faces leading to greater improvements in memory across sessions for same-race faces. However, Hispanic participants showed significant improvement for other-race, but not for same-race face memory, whereas memory improvement did not differ significantly for same- and other-race faces in the Caucasian participants.

During the process of consolidation, individual memories are transferred from a fragile to a more enduring state (Stickgold, 2005). Therefore, it was predicted that memories for same-race faces would be strengthened during consolidation resulting in greater memory improvement for same-race faces compared to other-race faces. However, this was not the case in the Hispanic participants. Another process that occurs during consolidation that may help to explain the results of the current experiment is gist extraction. During gist extraction, commonalities across recently learned items are identified and incorporated into existing knowledge networks resulting in new knowledge about underlying themes or the "gist" of this recently learned information at the expense of individual item details (Walker & Stickgold, 2013). This process could help explain the greater improvement in other-race face memory for Hispanic participants. It is possible that Hispanic participants had more elaborate existing knowledge networks for same-race faces compared with other-race faces. Therefore, memories for same-race faces may have been more easily assimilated into existing knowledge networks, making gist extraction more likely for same-race face memories compared with other-race face memories. If this was the case, the extraction of gist-level information at the expense of item-level details could have resulted in weaker memories for individual same-race faces compared with other-race faces in the Hispanic participant group. This consequence of consolidation could help explain the pattern of results observed here. However, it is unclear why the Hispanic participants would have more elaborate knowledge networks for same-races faces compared to the Caucasian participants.

Alternatively, as a minority group, Hispanic participants may have a heighted sense of awareness between the racial differences in the Hispanic and Caucasian faces. It may be possible that the minority Hispanic participants process same- and other-race faces utilizing separate knowledge networks, whereas the majority of Caucasian participants process both types of faces within the same network. Therefore, in the Hispanic group, the separate knowledge networks may be differentially affected during consolidation. However this is speculative and would require further investigation into the neural organization of these potentially separate networks utilizing techniques such as fMRI to make any conclusions.

These results could also be conceptualized in terms of face space. The face space hypothesis suggests that face representations are distributed across a multidimensional space (Caldara & Abdi, 2006; Valentine, 2001). Valentine (2001) and Valentine and Endo (1992) propose that same-race faces are widely distributed across this space while other-race faces are clustered more closely. The extent to which the structure of this space changes over time has not yet been examined. However, if changes are possible it may have been the case that the organization of face space in the Hispanic participants was altered in such a way that the distribution of other-race faces was broadened over the two-day delay period. If this occurred it would be expected that recognition accuracy would improve for other-race faces because individual other-race representations would be more easily accessed for recognition judgments. This is an interesting notion and future research might investigate the possibility of changes in face space during consolidation and how that might affect recognition of same-and other-race faces. Importantly, in the present experiment it is unclear why such changes would occur only for the Hispanic participants. Speculatively, the changes in facial representations in face-space could be modulated by factors such as fluctuations of perceptual expertise or perceptions of other-race faces overtime. Future modeling experiments including social factors are necessary to explore this possibility.

Although previous experiments indicate that consolidation occurs optimally during sleep (Stickgold & Walker, 2013), here, no relationships were observed between sleep quantity or quality and memory improvement across the 2-day delay period. Although self-reported measures of sleep were obtained, it is possible that these self-reports were not an accurate representation of participant's sleep quantity and quality. Therefore, future studies utilizing objective measures of sleep such as EEG would provide insights into the extent to which consolidation during sleep influences the recognition of same-and other-race faces over time. Although the Hispanic participants reported sleeping more soundly the night before session 1, this did not appear to influence encoding, as there were no differences on the initial recognition task.

Considering the social nature of this experiment, it is possible that a factor known as acculturation may have influenced the results. Acculturation describes the process by which members of different cultures adopt, partially or completely, elements of each other's culture (Berry, 1997). This process typically results in a non-dominant culture adopting elements of the dominant culture resulting in an unequal exchange. However, the extent of acculturation varies widely at the individual level and would have to be measured systematically to draw conclusions about the influence of this process on changes in memory for same- and other-race faces. Acculturation was not considered in the present experiment, but future studies might take this factor into account when examining changes in same- and other-race face memory over time.

Another consideration in the current experiment is the potential observation of a ceiling effect for same-race faces. In both the Caucasian and Hispanic groups the recognition scores for same-race faces were numerically greater than those for other-races faces during session 1. Therefore, the potential for an increase in recognition scores across sessions was not equivalent across same- and other-race faces. Future studies should control for this factor to mitigate the potential for a ceiling effect. Additionally, the sample size might be increased in future studies to ensure that the results observed here can be replicated.

Despite the limitations of the current experiment, the results suggest that memory for same- and other-race faces can change differentially over time, as was the case in the Hispanic participants. The ORE has important social implications and it is worth devoting time and effort to examine this phenomenon. In particular, this suggests that situations such as eyewitness testimony involving members of different ethnic groups may be influenced by the amount of time that has passed between the witnessing of an event and the recollection of the event. The literature concerning the ORE is vast and documents its consistency for short-term (i.e., on the same day) recall, but the current study suggests that extent of face-memory change can depend on the race of the perceiver. These results suggest that that we do not fully understand how consolidation influences the magnitude of the ORE over time, and future research should consider the role of consolidation and how it affects this well-known phenomenon.

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