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Category bias in facial memory

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Category Bias in Facial Memory

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Abstract

Existing knowledge has been shown to interact with episodic information in a variety of memory tasks. The present study examined a known bias due to existing knowledge in the context of memory for facial features. Specifically, we examined if the category bias, a systematic error in remembering a target toward the prototypical location of its region, increased as a function of distance away from its prototypical location and if time and degree of distortion moderated the bias. We manipulated eye width along a horizontal axis to create a set of face stimuli. In Experiment 1, participants saw one face at a time, and after a short delay, they were asked to reproduce the location of one of the eyes and complete a recognition task. In Experiment 2, we increased the delay from 2000ms to 5000ms. We hypothesized and found that bias towards the prototype increased for the moderately distorted face conditions; however, the decrease in bias in the highly distorted conditions was not statistically significant. Additionally, bias did not increase over time. We discuss our results in the context of Huttenlocher et al.'s (1991) category adjustment model, as well as the practical implications of our study in the field of eyewitness memory.

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Category Bias in Facial Memory

Existing knowledge plays a crucial role in our judgments about a stimulus (e.g., Hannigan & Reinitz, 2001). In spatial memory, one well-documented demonstration of the effect is referred to as the category bias (Huttenlocher, Hedges, & Duncan, 1991). The category bias is a systematic error in locating a stimulus in relation to the superordinate category to which the stimulus belongs. These distortions in memory of locations are very common and have been found with a variety of stimuli and tasks (Hund & Plumert, 2002; Sampaio & Wang, 2009). For example, judgments of relative location between two cities are biased according to the relative location of the states the cities belong to (Stevens & Coupe, 1978). Thus, individuals incorrectly infer that San Diego, California is to the west of Reno, Nevada presumably because of their knowledge that the state of California is generally to the west of the state of Nevada. More recently, the effect has been extended to memory for facial features, with the remembered position of an eye within a face showing a systematic bias towards the prototypical eye location (Sampaio & Symons, 2013). The study of biases in memory for faces not only is theoretically interesting but also has many practical implications.

Previous research suggests that people use a diverse array of cognitive processes to remember and distinguish between faces. These processes range from noting characteristics of individual features (e.g., eye color) to forming a spatial representation of the distance between features (see Maurer, Grand, & Mondloch, 2002 for a review). Biases in memory for faces, including the category bias, can shed light into the accuracy of the processes and products involved in choosing a person out of a lineup and of creating a sketch of a suspect's face. Similarly, discovering the variables that may moderate the effect of category bias in memory for faces has important practical applications in forensic settings.

Basic Processes in Face Recognition

Multiple processes have been proposed to explain how people remember and distinguish between faces. These processes fall under two broad categories. First, featural processing refers to using characteristics of individual features to remember and distinguish between faces. Second, configural processing refers to using the relationship between features to remember and distinguish between faces. Empirical evidence exists for each proposed mechanism, and the existing literature does not seem to allow for the identification of a dominant mechanism (see Rakover, 2002 for a critical review).

Featural processing involves using the characteristics of facial features to make discrimination and recognition judgments (Freire, Lee, & Symons, 2000). Evidence for featural processing stems from the observation that inverting a face decreases people's ability to use configural information to distinguish between and remember faces, but it does not affect their ability to use featural characteristics. For example, in a series of experiments, Freire et al. demonstrated that inversion impaired participants' ability to use configural information in visual discrimination and recognition tasks. Inversion did not, however, impair participants' ability to distinguish between and remember faces with feature manipulations. Specifically, in one experiment, participants accurately discriminated between inverted faces with featural differences. In a second experiment using a forced-choice recognition task, where the inverted target face and inverted foil face differed in feature characteristics, participants accurately chose the target face. Additionally, Barton, Keenan, and Bass (2001) found that inverting a face selectively disrupted participants' ability to discern changes in the distance between features but not for changes in eye color. Finally, Leder and Bruce (2000) found that inversion impaired participants' memory performance on a recognition task for faces with spacing manipulations but not for faces with hair, mouth, and eye color manipulations.

Similar to the inversion literature, neurological research provides additional evidence that featural and configural processing represent two discrete mechanisms in face processing. Le Grand, Mondloch, Maurer, and Brent (2001), for example, tested the ability of patients who had bilateral cataracts early in life to discriminate between faces with featural and configural manipulations. Specifically, patients viewed pairs of faces; some faces had different features (e.g., different mouths), and some faces had spacing differences (e.g., the distance between the eyes differed between the faces). Patients were sensitive to featural changes; however, compared to controls, patients performed poorly when discriminating between faces that differed in the spacing between features. The purpose of the experiment was to determine if a critical period for developing the ability to use configural information exists, that is, the study sought to determine whether people who are born blind and regain their sight later in life can develop the ability to use configural information. The results showed that patients could only use featural information to distinguish between faces, and controls could use configural or featural information (depending on the stimuli), demonstrating that featural processing represents a discrete mechanism in face processing.

In contrast to featural processing, configural processing refers to the way in which people use the entire face during recognition. Holistic processing represents one of three subtypes of configural processing. In holistic processing, the entire face is encoded as a complete, integrated unit. Research supporting holistic processing focuses on how people remember facial information better when it is given in the context of the whole face. For example, Farah, Wilson, Tanaka, and Drain (1998) found superior recognition accuracy for faces that were identical to acquisition items or completely different. Participants performed significantly worse on a recognition test when the face contained a target feature from the old face and the irrelevant, or foil, features were different (e.g., the same eyes as the old face but a different jaw, nose, mouth, etc.). Valentine and Bruce (1986a, 1986b) observed that their participants were significantly slower in recognizing jumbled, distinctive faces than recognizing jumbled, prototypical (i.e., average looking) faces. Both Farah et al. and Valentine and Bruce argue, albeit using a different vocabulary, that face recognition involves a matching process, whereby people use their memory for an entire face as a template and attempt to match it to the face they are trying to identify.

A second subtype of configural processing is first-order relational processing. This type of processing involves using the basic relationship between features to identify stimuli as faces; for example, eyes are always above the nose, and the nose is always above the mouth. Imaging research using fMRI supports first-order relational processing by demonstrating a distinctive pattern of neural activity when people view faces over other types of stimuli (Haxby et al., 2001). Moreover, Baenninger (1994) tested recognition accuracy for faces with configural modifications and found a significant decline in accuracy when the faces contained disrupted first-order relations (e.g., the nose located at the top of the head).

The third subtype of configural processing is second-order relational processing. This type of processing refers to the ways in which people use spatial relations between features to remember and discriminate between faces. People display a remarkable level of accuracy for detecting these distances. Using a simple recognition task (i.e., at recognition, participants were asked to judge if the presented face was the same or different as the acquisition face), Haig (1984) observed that his participants' just noticeable difference (JND) for eye movements was between 1.75 and 2.53 pixels. Evidence for the importance of second-order processing comes from the observation that inverting faces both impairs recognition accuracy (e.g., Yin, 1969; Rhodes et al., 1989) and impairs people's ability to accurately gauge distances between features (Barton et al., 2001; Leder & Bruce, 2000). Specifically, the inversion literature demonstrates that when faces are upright, people use spatial relationships to make accurate discrimination and recognition judgments.

In sum, facial memory involves featural processing and three types of configural processing. Holistic processing refers to using the entire face as a template and engaging in a matching process (Valentine & Bruce, 1986, 1986b; Farah et al., 1998). First-order relational processing refers to using basic relationships between features to recognize stimuli as faces (Haxby et al., 2001; Baenninger, 1994). Second-order relational processing refers to the way in which people use spatial relationships to recognize faces and discriminate between faces (Haig, 1984; Barton et al., 2001; Leder & Bruce, 2000). While evidence exists for all types of processing, there is no clear conclusion about which process is dominant (Rakover, 2002)

Schemata

Examining facial memory using schema theory may help elucidate a specific process through which facial memory, or at least reports from memory, can become biased. All schema theories propose that existing knowledge structures provide a context for encoding new information and that existing knowledge affects what information is encoded (Alba & Hasher, 1983). Minksy's (1975) frame theory, for example, offers a useful way to conceptualize the way in which a schema serves as a template for encoding new information. Minsky uses the term "frame" to describe the existing knowledge structure that represents a schematic instance (p. 1). Within each frame, multiple terminals exist for representing detailed information. For example, an office frame may have a terminal for a desk, chair, bookshelf, computer, etc. Each terminal comes already assigned with a default value (i.e., an average looking desk, chair, bookshelf, etc.). When a person encounters a new office, the existing frame functions as a template, and the person adjusts default values to account for specific details (e.g., noting the specific type of desk). If a person fails to encode details for a terminal, default values are automatically used.

The formation of a face schema or prototype may reflect some measure of central tendency (Solso & McCarthy, 1981). For instance, in their experiment, Solso and McCarthy took a generic face template used by police and generated variations from it in such a way that that some features occurred at a higher frequency (e.g., one particular mouth occurred at a higher frequency in the acquisition stimuli). During the acquisition phase, participants viewed ten variations of the prototype face but not the prototype itself. The recognition test immediately following encoding, as well as a second test that occurred six weeks later, revealed that while in general participants displayed high levels of accuracy in distinguishing old from new faces, the prototype face elicited extremely high false alarm rates (only one subject did not falsely recognize the prototype). Additionally, participants had higher confidence levels for the prototype face than for the faces they actually viewed. Solso and McCarthy suggested that people may generate a prototype based on the integration of multiple frequency distributions. In Solso and McCarthy's study, people seem to have combined the modal facial features in the acquisition stimuli to generate a prototypical face. Although the Solso and McCarthy's (1981) study examined the formation of a prototype based on integrating modal facial features, a similar process could account for the formation of a prototype based on the location of facial features or the spatial relationships between features. For example, a person may generate a frequency distribution for the width between a person's eyes. Eye width on their prototype face reflects the mean width from a frequency distribution. This complex, unconscious process may represent the underlying process in schema formation.

Research using word lists as the stimuli has found similar results. For example, Roediger and McDermott (1995) used Deese's (1959) original word lists, built around a critical word (e.g., a word list containing a list of specific types of fruit when the critical word is "fruit"), to test memory. Recall rates for non-presented, critical words were equal to or greater than the items participants studied. During recognition testing, participants displayed approximately equal false alarm and hit rates; that is, participants were just as likely to recognize the non-presented, critical words as the words they actually viewed during the acquisition phase. Additionally, participants expressed high confidence levels for critical words. As one possible explanation, Roediger and McDermott suggested a schema-based hypothesis for their results; specifically, the critical words may represent the prototype for the word lists, and participants were making schema-based inference errors.

Selection represents one of the basic mechanisms of schemata (Alba & Hasher, 1983). Selection refers to the way in which existing knowledge structures influence which stimuli are attended to and thus remembered. Specifically, highly developed knowledge structures, or schemata, allow for efficient integration of new information. In contrast, adding new information without a background context is a relatively inefficient process.

Face memory research has shown that face schemata facilitate memory for schematic faces and that the absence of a schema for a type of face (e.g., inverted or other-race faces) hinders memory. For instance, Goldstein (1975) demonstrated that inversion affects recognition accuracy for adults more than it does for children. Goldstein suggests that the development of highly tuned facial schemata may help adults remember upright faces but detract from their ability to recognize schema atypical, inverted faces. Additionally, Goldstein and Chance (1980) demonstrated that children show less susceptibility to the own-race effect (i.e., the tendency to make significantly more errors when trying to remember faces of a different race). Goldstein and Chance's study revealed that Caucasian children's memory for Japanese and Caucasian faces increases through grade six. During that time, children show similar accuracy levels for both types of faces. In contrast, Caucasian adults display a wide discrepancy in recognition accuracy levels between Caucasian and Japanese faces. Similar to the schema explanation for inversion effects, Goldstein and Chance argue that—because prolonged and repeated exposure leads to complex but inflexible face schemata—adults have finely tuned own-race face schemata that help them remember schematic faces but detract from their ability to remember schema atypical faces.

Although evidence demonstrates that schemata provide a template for encoding that enhances memory, other research suggests that schema atypical stimuli may draw additional attentional resources that enhance memory (Johnston, Hawley, Plewe, Elliott, & DeWitt, 1990). In their experiment, Johnston et al. presented participants with long sequences of four words arranged in a spatial configuration (i.e., an array consisting of four boxes). Some words occurred at a high frequency (familiar words), while other words appeared infrequently (novel words). On each trial, participants viewed an array with a different word in each of the four boxes. Following a delay, participants viewed the same array with the probed word in all four boxes. Participants then indicated the location of the probed word in the array they viewed during the acquisition phase; for example, if the word "dog" appeared in the top box during the acquisition phase, the participant should select the top box during the test phase. When compared with familiar words, participants displayed higher levels of accuracy for the infrequently occurring, novel words, an effect the authors termed "novel pop out."

After a series of replications (Johnston, Hawley, & Farnham, 1993), Johnston, Hawley, and Farnham (1994) proposed mismatch theory. Mismatch theory postulates that when viewing familiar stimuli, schema-driven processing dominates and serves to conserve cognitive resources; moreover, an inhibition of data-driven, bottom-up processing accompanies schema-driven processing. However, upon viewing a schema atypical stimulus, "novel pop out" shifts perception to data-driven processing. Johnson et al. conjecture that the "novel pop out" effect serves an evolutionary function by counterbalancing top-down, schema-driven processing.

Research using scenes as stimuli provides additional evidence for the attention postulate of schema theory (Friedman, 1979). Friedman presented participants with scenes containing schematic and schema atypical stimuli. During the experiment, participants' eye movements were monitored. Results indicated that participants spent more time starting at schema atypical stimuli, suggesting that schema consistency affects attention allocation. Additionally, recognition testing revealed that participants were more likely to notice changes in schema atypical stimuli and make correct rejections.

Additional evidence for the attention postulate of schema theory using scenes as stimuli comes from Gordon (2004). Gordon presented participants with scenes containing schematic (e.g., a motorcycle at a gas station) and schema atypical (e.g., a harp at a gas station) stimuli. Following a delay, participants were shown a probe (an ampersand or percentage sign) and were instructed to press the mouse key corresponding to the correct symbol (e.g., left click if the symbol is an ampersand). When participants viewed scenes for longer than 150ms, they showed faster reaction times when the symbol occurred at the location of the schema atypical object. This suggests that participants focused their attention on the location of the schema atypical stimuli, providing additional support for the attention postulate of schema theory.

In addition to previously discussed stimulus domains, evidence suggests that the attention postulate of schema theory applies to facial memory (Perkins, 1991). Perkins examined the role of attention and schemata in the context of facial memory by presenting participants with either a schematic face or a schema atypical face (e.g., a face with the nose located on top of the head). At recognition, participants were presented with two cards containing the target feature and a distracter feature, both in isolation (e.g., two noses). The results of the forced-choice recognition test indicated that participants were more accurate at recognizing features from schema atypical faces, suggesting that participants allocated their attention to the schema atypical faces, which enhanced recognition accuracy.

In sum, research suggesting that, through exposure, people develop complex schemata for own-race and upright faces that enhance memory is supported by the observation that exposure duration is associated with increased recognition accuracy for frequently seen faces and decreased recognition accuracy for infrequently seen faces (Goldstein, 1975; Goldstein and Chance, 1980). In contrast, a separate body of literature suggests that schema atypical stimuli—including faces—affect attention allocation and recognition accuracy (Friedman, 1979; Johnston et al., 1990; Perkins, 1991; Gordon, 2004). Although this research may seem contradictory, Johnston et al.'s conjecture that schema-driven processing and processing associated with the "novel pop out" effect both occur and counterbalance each other offers a resolution.

In addition to providing a template for encoding and influencing attention, multiple studies have demonstrated the effect schemata have in guiding responses in recall and recognition tasks. For example, in a classic study, Bartlett (1932) observed that his western participant sample profoundly altered a Native American folktale during a recall test; specifically, they modified the structure and content in the direction of a schematic story from western culture (as cited in Brewer, 2000). Brewer and Treyens (1981) brought participants into a graduate student's office under the guise that they needed to wait until the experiment was ready. Afterwards, participants' memory for objects in the office was tested. An examination of errors in recall and recognition tests revealed that participants inferred the presence of objects typically found in a graduate students office (e.g., books and pencils) that were absent from the office, which suggests that episodic information becomes integrated with existing, schematic knowledge for offices. Similarly, Hannigan and Reinitz (2001) demonstrated inference errors in procedural schemata (e.g., remembering buying meat at the grocery store when that event was absent from the acquisition phase) and causal-inference errors (e.g., remembering someone taking an orange from the bottom of the pile when shown a picture of oranges all over the floor in the acquisition phase).

In the context of facial memory, schemata may also guide responses. Goldstein, Stephenson, and Chance (1977) analyzed false alarm results from six studies. Frequency distributions revealed that certain faces consistently elicited false alarms; that is, the distribution of false alarms among foils was non-random. Offering a possible explanation, Goldstein et al. postulated that faces eliciting high false alarm rates may represent a prototype; that is, the faces may appear as a composite of modal facial features from the population. Solso and McCarthy's (1981) observation that participants expressed more confidence in having seen a prototype face, generated by integrating modal features, than for the faces they actually viewed supports Goldstein et al.'s conjecture.

Schemata and Spatial Memory

Huttenlocher et al.'s (1991) category adjustment model (CA) represents a version of schema theory that was developed to examine spatial memory; therefore, it is a useful model for examining second-order relational processing (i.e., people's memory for spatial relationships between features) in facial memory. Consistent with schema theory, the model proposes that existing knowledge structures influence the processing of and memory for incoming information. Unlike schema theories that make qualitative predictions about the effect of schemata on memory (e.g., testing recognition accuracy for schematic vs. atypical stimuli), the CA model details an underlying mechanism, based on Bayes' principles, that explains how spatial category (a coarse-grain representation) and coordinate information for a target location (a fine-grain representation) interact.

The CA model is related to Minsky's (1975) frame theory. Through the process of coarse-grain coding, people divide a space into categories. Within each category, people generate a central, prototypical location; that is, the prototype reflects the location that would minimize variance if a person guessed the location of a target location over repeated trials. Central to the CA model is the idea that a new target location is encoded as a distribution of values, and the precision of encoding determines the spread of the distribution. A fine-grain value refers to a sample from the distribution of values. At the time of recall, a subject weighs the fine-grain value with the coarse-grain representation based on the relative strength of these representations (Huttenlocher et al., 1991). For example, applied to face memory, the CA model would suggest that if the subject only has a vague memory for the eye location, they may rely heavily on their knowledge of a prototypical eye location, and place the recalled eye close to the prototype. At the extreme, if there was no fine-grain representation, the prototype would be used to estimate the location of a specific eye.

The category, defined as the distribution of values within category boundaries, interacts with coordinate, fine-grain memory during the recall test. For example, during a recall task, a subject may use their memory for the specific eye they viewed during the acquisition phase and their knowledge of a prototypical eye location (i.e., coarse-grain representation) to produce an answer. The coarse-grain representation and fine-grain value differentially affect recall responses depending on the weight placed on each value. Consistency determines the prototype's weight; for example, in memory for eye location, if a subject knows that the eyes are always located in a specific spot, they will heavily weight the coarse-grain representation. The prototype is thought to function to reduce variance; that is, if a subject only has a vague memory of where the eye is in a particular face, choosing the average location in a memory test will, over repeated trials, reduce the mean distance between the real location and the recalled location (Huttenlocher et al., 1991).

Through the process of truncation, category boundaries confine recalled locations to the category. Specifically, truncation refers to the process whereby people's memories for stimulus values that occur outside inexact category boundaries adjust inwards towards the prototypical location. For example, if a subject viewed a circle with a dot located slightly outside the category boundary (i.e., the quadrant of the circle in which the dot is located), the subject may place the dot inside the quadrant at recall. In addition, the strength of truncation varies as a function of category boundary inexactness. Specifically, truncation effects increase as category boundaries becomes more exact (i.e., a single value) and decrease as a category boundaries become more inexact (i.e., a range of values). With circular spaces, Huttenlocher (1991) notes that boundary inexactness results from having to eyeball the location of the axes dividing the circle into quadrants.

In a series of classic experiments, Huttenlocher et al. (1991) tested the predictions of the CA model by examining the pattern of dot localization within a circle; specifically, participants viewed a series of circles, each containing one dot. Combined, the test stimuli set included dots evenly distributed over the entire circle. After viewing each circle, participants completed a recall test. Participants displayed a bias away from vertical and horizontal lines, suggesting that participants mentally break the circle into quadrants when encoding dot location; that is, they generate category boundaries. Furthermore, bias towards a prototypical location (i.e., in between the center of the circle and the circumference and along a 45-degree angle) increased as a distracter task depleted participants' attentional resources. Taken together, the results of the experiments provide support for the idea that recall responses reflect an interaction between fine-grain and coarse-grain representations.

In addition to depleting attentional resources, evidence suggests time increases category bias. Using a square space (model house), Hund and Plumert (2002) tested the effect of delay on category bias. Compared with participants tested immediately after encoding, adults and children tested after a 12-minute delay demonstrated an increased reliance on the category; that is, participants displayed a pattern of bias towards the center of the quadrant in which the encoded object was located. Additionally, Sampaio and Wang (2012) manipulated the delay between encoding (500ms or 3000ms) and retrieval. Results indicated that time increased the level of bias created by the new category. The increase in bias seems to reflect Huttenlocher et al.'s (1991) assumption of the faster rate of decay of the fine-grain representation compared to the coarse-grain representation.

Although Huttenlocher et al. (1991) originally used the CA model to test memory for dots inside circles, the model has been extended to other domains such as geography (Friedman, 2009) and other spaces such as locations within a college campus (Uttal, Friedman, Hand, & Warren, 2010; Sampaio & Cardwell, 2012). Sampaio and Symons (2013), for example, took the CA approach to investigate memory for a facial feature location. Merged with the face inversion effect in perception (Yin, 1969), they hypothesized that because of extensive exposure to upright faces, people develop a generic face prototype that affects which information in a particular face is encoded. They further hypothesized that people hold a more finely-tuned prototype for feature locations in upright faces than in upside down faces. At the time of retrieval, the position of a feature should be adjusted with the prototypical location of that feature within a prototypical face. Based on Huttenlocher et al.'s (1991) category adjustment model, they expected and found that the prototype value on upright faces is indeed more precise/less variable than that in inverted faces, and that memory for specific feature locations in the former case showed a larger category bias than in the latter case. They interpreted the results as indicating that the relative weighing of the fine-grain and coarse-grain representations in facial feature localization is a function of the participants' degree of certainty.

Experiment 1

Recent data show that people hold a face prototype for upright faces and that category bias operates in facial memory. However, research has not yet examined what variables may moderate the category bias in facial memory. In Experiment 1, we examined how degree of distortion away from a prototype affected the magnitude of the category bias. We hypothesized that when viewing prototypical stimuli or stimuli that are moderately distorted from the prototype, participants would rely on their coarse-grain representation, which would be reflected by increasing levels of bias as the distance away from the prototype increased. When viewing stimuli highly distorted from the prototype, however, we predicted an increase in fine-grain exactness, which would be reflected by a reduced bias in recalled, extreme eye locations. We manipulated the distance between the eyes to create a set of faces that contained eyes located moderately distant from the eyes' prototypical location and a set of faces that contained eyes located highly distant from their prototypical location (e.g., at the extreme, these faces have eyes touching at the center). It was hypothesized that memory performance would be low for the moderately distorted stimuli (Sampaio & Symons , 2013), as it was expected that estimation of location from memory would heavily reflect the weight of the prototypical location of the eye. In contrast, it was hypothesized that performance would be higher for estimates of extreme eye location, as it was expected they would reflect a heavier weight of the fine-grain representation compared to the moderately distorted stimuli.

By examining the role of distortion away from the prototype in moderating the magnitude of category bias, the present study may help resolve inconsistencies in the literature regarding the effect of schema consistency on facial memory. Previous research has demonstrated that sometimes schema-inconsistent information enhances memory (e.g., Perkins, 1991), and at other times it hinders memory (e.g., Goldstein, 1975). In this project, we tried to address the question of whether level of distortion from the prototype/schema can explain the discrepancy; that is, we hypothesized that the degree of distortion plays a crucial role in memory for schema atypical information, with the degree of distortion from a schema/prototype determining fine-grain inexactness. With respect to this project, we hypothesized that the magnitude of the bias would vary as a function of the level of distortion of a particular eye location from its prototypical location. Specifically, we expected that the magnitude of bias would increase as the degree of distortion increases, but only for moderately distorted stimuli, as in Sampaio and Symons (2013). However, as eye location starts to be highly distorted from its prototypical location, performance would improve, perhaps because people would start noticing the distortion from the prototype; that is, the relative weight placed on the coarse-grain and fine-grain representation would shift, resulting in reduced bias towards the prototype.

The first experiment included three phases, including a prototype identification task, a recall task, and a recognition task. Because we examined bias that results from integrating a prototypical eye location, the first phase of the experiment served to identify the prototypical eye location. Participants marked where they thought the prototypical location of each eye was for faces with eyes removed. Second, participants completed a recall task for eye location. Third, participants completed a multiple-choice recognition task. It was hypothesized that eye location in moderately distorted faces would show lower accuracy than in highly distorted faces, because high distortions would reduce fine-grain inexactness, resulting in a shift in the weight placed on the prototype and the fine-grain value.

Method

Participants

Twenty-nine Western Washington University undergraduate psychology students recruited through the SONA system participated in this study for course credit. Fourteen participants were male, and 15 participants were female. Twenty-seven participants were right handed, and two participants were left handed.

Materials

Acquisition Items.

Twelve face sets were created. From each of the 12 base faces, eight variations were created by changing the spacing between the eyes, for a total of 96 acquisition faces. All faces were adult Caucasian males. The eye spacing on each face was adjusted inward and outward, with the exact spacing amount dependent on the width of the face. The width adjustment for all eight variations was identical. Eyes were moved along a horizontal axis, and width adjustments ranged from four to eight pixels. Four faces had four pixel adjustments, four faces had five pixel adjustments, three faces had six pixel adjustments, and one face had eight pixel adjustments. When viewed on the computer monitors used for the experiment, mean face width was 164.75 millimeters (*SD* = 13.53), and mean face height was 259.25 millimeters (*SD* = 7.50).

Test Stimuli.

For the recognition test, all 96 acquisition faces were used to create 12 multiple-choice arrays (12 arrays displaying all 8 variations of a base face); each array included eight faces with equal spacing measurements. We numbered faces one through eight, with one denoting the face with eyes touching in the center and eight denoting the face with eyes touching the outer edge of the face (see Appendix A and B for complete list of stimuli used in experiment). In addition, for the recall test, there were 12 response faces created by removing the eyes on the base faces and filling in the space with a neutral skin tone.

Design

The present study used a fully within-participants design. In the first phase of the experiment, participants were presented with all 12 base faces and marked where they thought the pupil should be located. In the second phase, all participants viewed all 96 face stimuli twice. For the first block of 96 faces, participants reproduced the location of the eye on the right side of the screen. For the second block of 96 faces, participants reproduced the location of the eye on the left side of the screen. In the third phase of the experiment, all participants viewed all 96 faces and completed a recognition test. For both the recall and recognition test, the order the faces appeared in was randomized.

Procedure

Upon arriving to the lab, the experimenter directed each participant into one of four private rooms, each containing a desktop computer. We used E-Prime software to administer the experiment. The experimenter started the program, entered the participant number, the session number, the participant's sex, entered their handedness (determined by asking the participant), and their own researcher ID number. After reviewing the accuracy of the information, the experimenter started the program and returned to the center room. Next, a screen displayed instructing participants to use their mouse curser to mark where they thought the pupil of an eye should be. When viewed on the computer screen, faces were looking straight ahead. After pressing the space bar, a second screen appeared reiterating the instructions. After pressing the space bar a second time, a priming screen appeared telling participants whether to mark the location of the pupil on the right or left side of the screen. Next, a face where the eyes had been replaced with a neutral skin tone appeared, and participants used their mouse curser to mark the location of the right or left pupil. The process repeated until the participants marked pupil location for all 12 base faces.

Upon completion of the prototype identification stage, a screen displayed that instructed participants to remember the position of the eye on the right side of the screen for the first set of faces and the eye on the left side of the screen for the second set of faces. For each trial, a face appeared for 300ms, followed by a mask for 500ms (a red grid) and a black screen for 1500ms (for a total of 2000ms delay). After 2000ms, an eyeless response face corresponding to the acquisition face appeared, and participants market their recalled location of the eye using the mouse curser. After marking their recalled location, a screen appeared instructing participants to rate their confidence by selecting a key from 1 to 7, with large numbers indicating higher levels of confidence. After participants completed the first block of 96 faces, an intermission screen appeared instructing participants to remember the location of the left eye. The second test block was identical to the first block.

Upon completion of the recall task, a screen displayed instructing participants to remember the face they were about to see. After pressing the space bar to start the test, a single face appeared for 300ms, followed immediately by the multiple-choice test screen displaying eight variations of the face they viewed. Participants indicated the face they recognized by pressing the numerical key corresponding to their selection. After making their selection, a screen displayed asking participants to use the same 7-point confidence scale to rate their level of confidence. This process repeated for all 96 faces.

Results

Experiment 1 tested the role of level of distortion away from a prototype in moderating category bias in facial memory; specifically, we predicted that bias would increase as a function of distance away from the prototype. However, in the extremely distorted conditions, we predicted a decrease in bias resulting from the effect of schema-inconsistency; that is, schema-inconsistency would result in a heavier weight being placed on participants’ fine-grain representation.

To prepare the data for analysis, we first eliminated face one from the analysis, as the inward and outward manipulations different by one unit, making this face different from faces two through 12. Specifically, pixel width between all eight conditions was not equal in face one. Second, to prevent outliers from impeding identification of accurate prototype, we trimmed values exceeding 25 units away from a central eye location (manipulation condition 4) (n = 9 or 5.7% of the data). Although the chosen, central location was arbitrary, 77% of trimmed outliers exceed 94 units away from manipulation four, meaning—in addition to being on the other side of the screen—they would be in excess of 25 units away from any of the face manipulation conditions. Third, we trimmed recall responses exceeding 25 units (n = 148 or 6.6% of the data) away from the true location; keeping these aberrant data would unjustly inflate our effect size. Fourth, because the program used for the experiment had a glitch, all left eye location values had the same number; we removed these data from our analysis. We followed the standard procedure to quantify bias, by subtracting the true location from the recalled location. To examine differences in confidence and reaction time between correct and incorrect responses, we created a dummy coded column for recall and recognition data. For recall data, a zero denotes that the recalled location was within 3 units of the true location, and a one denotes that the recalled location exceeded 3 units away from the correct location. For the recognition test, a zero denotes that the participant chose the correct face.

This study examined bias as a function of distance away from a prototypical eye location. To identify the prototypical location, we calculated the mean selected x coordinate (i.e., the location on the horizontal axis) for right eye location for each face, as well as the average location for the face set. Next, we performed a two-tailed, one-sample t-test comparing participants' selected prototype eye location to the closest manipulation condition. Participants' selected prototype (M = 374.78, SD = 6.45) was not significantly different from eye location in condition five (M = 376.55), $t(28) = -1.48$, $p > .05$.

We analyzed recall data using a within-participants ANOVA. Our data did not meet the sphericity assumption; therefore, we interpreted our results using the Huynh-Feldt adjustment. The ANOVA revealed a main effect of distance away from the prototype on bias, $F(1.96, 53) = 7.42$, $p < .05$, *partial* $\eta^2 = .215$. Planned polynomial contrasts revealed that our data follow a significant cubic trend; that is, bias increased as a function of distance away from the prototype, and participants adjusted responses inwards from the edge of the face and outwards from the center of the face, $F(1, 27) = 6.11$, $p < .05$.

Although the cubic trend emerged as significant (see figure 1), we tested the significance of the reduction in bias by performing a linear regression using manipulation conditions two through seven. If the trend was linear (i.e., there was no drop in bias in the extreme conditions), the predicted values from the regression for manipulation conditions one and eight should not be significantly different from the obtained values. We performed one-sample t-tests comparing the obtained values against the predicted values. Manipulation condition one (M = 1.70, SD = 5.14) was not significantly different from the predicted value (M = 2.994), $t(27) = -1.33$, $p > .05$. Manipulation condition eight (M = -2.64, SD = 5.3) was not significantly different from the predicted value (X = -3.5), $t(27) = .859$, $p > .05$. In sum, although the upward trend in bias as eye location moved away from the prototype decreased abruptly in the extreme conditions, the reductions were not significantly different from a linear trend.

Following Haig's (1984) observation that his participants were more sensitive to inward than outward horizontal eye manipulations, we compared the absolute value of inward and outward manipulation bias using a paired samples t-test. The test revealed that the difference in bias between outward (M = 3.34, SD = 2.44) and inward (M = 3.07, SD = 2.19) manipulation conditions was not significantly different, $t(27) = -.373$, p = > .05.

Turning to recognition data, a X^2 test of independence revealed that the face participants recognized face was dependent on the face they viewed during the acquisition phase, $X^2(49, N = 2552) = 5019$, $p < .001$. Descriptive statistics (see Table 1), suggest that when participants committed a false alarm, the majority adjusted their responses outwards in manipulation conditions one, two (88.2%), and three (77.1%). Additionally, most participants adjusted their responses inwards in manipulation conditions eight, seven (88.5%), and six (77.9%). In manipulation conditions four and five, Q-Q plots suggest false alarms are relatively evenly distributed around the prototype. This observation, however, needs to be interpreted cautiously, as both distributions failed Kolmogorov-Smirnov's test of normality.

Confidence levels for recall responses within 3 units of the true location (*M* = 4.92, *SD* = .85) were significantly higher than confidence responses for recalled locations exceeding 3 units away from the true location (*M* = 4.78, *SD* = .89), $t(27) = 2.61$, $p = < .05$. Examining recognition data, participants were not more confident when they chose the correct (*M* = 5.27, *SD* = .783) location over the incorrect location (*M* = 5.274, *SD* = .78), $t(28) = -.117$, $p = > .05$.

We examined the effect of manipulation condition on reaction time using within-participants ANOVA. To adjust for a violation of sphericity, we interpreted the results using the Huynh-Felt adjustment. The ANOVA revealed a main effect of manipulation condition on reaction time, $F(6.08, 164.14) = 2.16$, $p = < .05$, *partial* $\eta^2 = .074$. Planned pair-wise comparisons between conditions one (*M*= 2295.71, *SD* = 1022.14) and two (*M* = 2165.67, *SD* = 927.13) revealed a borderline statistical trend $t(27) = 1.61$, $p = .12$. Planned pair-wise comparisons between conditions seven (*M* = 2141.5, *SD* = 163.58) and eight (*M* = 2342.06, *SD* = 174.2) revealed a significant increase in reaction time, $t(27) = -2.411$, $p = < .05$. Manipulation condition did not affect reaction time for recognition responses, $F(5.75, 137.89) = .993$, $p = > .05$, *partial* $\eta^2 = .04$.

Turning to reaction time and accuracy, a paired samples t-test revealed that participants displayed shorter reaction times when recalling a location within three units of the true location (*M* = 2097.6, *SD* = 827.052) than when recalling a location exceeding three unites away from the true location (*M* = 2252.18, *SD* = 882.12), $t(27) = -.2.84$, $p < .05$.

Additionally, participants displayed significantly shorter reaction times when recognizing the correct face (*M* = 714.52, *SD* = 188.09) than the incorrect face (*M* = 885.93, *SD* = 256.85), $t(28) = -4.65$, $p < .001$.

Discussion

Results from Experiment 1 are consistent with previous work demonstrating the category bias in facial memory (Sampaio & Symons, 2013). Recall data demonstrated that participants adjusted their responses towards a prototypical eye location, with the level of bias increasing as a function of distance away from the prototype. The pattern of false alarms obtained in the recognition test also confirms the category bias; that is, when participants chose the incorrect face, they selected faces with eyes closer to the prototype.

Experiment 1 found a mean decrease in bias in the extreme conditions; however, the decrease did not approach statistical significance. Given the small effect size of the omnibus ANOVA and the subtlety of the biases, the lack of statistical significance may reflect a lack of statistical power. Response time data reveal that participants took significantly longer when making a recall response in condition eight than in condition seven. The increase in reaction time between conditions two and one narrowly missed being a statistical trend. The significant increase in reaction time demonstrates that a change is occurring between the moderately and highly distorted conditions; however, interpreting the meaning of the increase in reaction time in the context of the CA model and schema-consistency literature requires additional investigation.

Participants displayed significantly reduced response times when recalling a location within three units of the true coordinates. Additionally, participants displayed higher confidence levels when recalling a location within three units of the true coordinates. A relationship between confidence and response time may exist, whereby participants make faster decisions when they are confident in their responses. Additionally, mean biases were lowest at the prototype, suggesting that many of the correct recall responses occurred at or near the prototype. At the prototype, coarse-grain and fine-grain representations reinforce each other, and relying on either representation—or any differentially weighted combination—would yield an accurate response. Consistency between these representations may account for the decrease in response times.

Experiment 2

Time is known to affect the degree of category bias in spatial memory tasks, such that in general there is a larger bias with time (Hund & Plumert, 2002; Sampaio & Wang, 2012). The effect is thought to be due to the coordinate information fading more rapidly than the spatial category, and thus in estimating locations from memory, more weight is given to the former rather than the latter. Experiment 2 examined the effect of time on category bias in the context of facial memory. In Experiment 2, we increased the delay from 2000ms to 5000ms. In Sampaio and Wang (2009), a response time of 5000ms was used in the long-delay condition. We continued to manipulate distortion away from the prototype by varying eye location.

Method

Participants

Twenty-two Western Washington University undergraduate psychology students recruited through the SONA system participated in this study for course credit. Nine participants were male and 13 participants were female. Two participants were left handed and 20 participants were right handed.

Materials

The same materials used for Experiment 1 were used for Experiment 2. To keep the experiment under 60 minutes and prevent participant fatigue, Experiment 2 randomly selected and used six base faces instead of 12. The prototype identification stage used six base faces without eyes. Acquisition stimuli for the recall and recognition task consisted of 48 faces, six base faces with 8 equal horizontal eye manipulations. Test stimuli for the recall task consisted of six response faces with the eyes removed and filled with a neutral skin tone. Test stimuli for the recognition task consisted of six multiple-choice slides in the same configuration as Experiment 1.

Design

Experiment 2 used a fully within-participants design. The prototype identification stage consisted of six trials, one for each base face. The recall test consisted of 96 trials divided into two blocks. The multiple-choice recognition test consisted of 48 trials in a single block. For both the recall and recognition task, participants viewed all six base faces in all eight configurations. For both the recall and recognition test, we randomized the order the faces appeared in.

Procedure

Experiment 2 used the same testing procedure as Experiment 1; however, we increased the delay from 2000ms to 5000ms.

Results

Experiment 1 examined the effect of schema inconsistency in moderating the category bias in facial memory. To test a second moderating variable and elaborate on the results obtained in Experiment 1, Experiment 2 examined the effect of time in moderating the category bias, as well as the persistence of schema atypical effects.

We performed the same data preparation procedures as Experiment 1. For the prototype data, we trimmed eight values (13% of data set); all values exceeded 91 units away from condition four. For the recall data, we trimmed 108 values (11.7%) of data set. Additionally, subject nine told the experimenter that they did not become aware of the instructions until halfway through the experiment; we excluded this participant from the analyses.

We performed one-sample t-tests comparing participants' selected prototypical eye location against the closest face manipulation condition. Participants' mean selected prototype eye location (M = 375.41, SD = 5.25) was closest to manipulation condition four (M = 372.8), $t(19)$ = 2.22 , p = < .05. Experiment 2 used fewer faces to keep the experiment within 60 minutes; this may account for the discrepancy in prototype faces between Experiment 1 and two.

Figure 2 displays bias plotted against manipulation condition. We performed a within-participants ANOVA to test the effect of manipulation condition. Our data did not possess sphericity; therefore, we interpreted our results using the Huynh-Feldt adjustment.

The ANOVA revealed no main effect of manipulation condition on bias, $F(2.26, 42.96) = .804$, $p = .468$, *partial* $\eta^2 = .041$.

Turning to recognition data, a X^2 test of independence revealed that participants' recognized face was dependent on the face manipulation condition viewed during the acquisition phase, $X^2(49, N = 880) = 2157$, $p < .001$. Recognition results (see Table 2) partially resemble the pattern found in Experiment 1. When participants committed a false alarm in manipulation conditions one, two, and three, the majority of participants adjusted their responses outwards. In manipulation conditions eight, seven, and six, the majority of participants adjusted their responses inwards. Unlike Experiment 1, however, false alarms were not evenly distributed around manipulation conditions four and five. The same sample that yielded the bizarre response patterns in the recall task may account for this discrepancy.

Confidence levels for recalled locations within 3 units of the correct location ($M = 4.81$, $SD = .84$) were not different from confidence levels for recalled locations exceeding 3 units away from the true location ($M = 4.75$, $SD = .68$), $t(19) = .771$, $p = .45$. Examining recognition data, confidence levels for correct responses ($M = 5.57$, $SD = .55$) were significantly higher than confidence levels for incorrect responses ($M = 5.03$, $SD = .52$), $t(20) = 8.104$, $p < .01$.

We used a within-participants ANOVA to examine the relationship between manipulation condition and reaction time. The data met the sphericity assumption, $X^2(27) = 31.49$, $p = .265$. Similar to the lack of an effect in the omnibus ANOVA for bias, eye location did not affect reaction time, $F(7, 133) = .612$, $p = .745$, *partial* $\eta^2 = .031$. A statistical trend suggests than participants may display lower reaction times when recognizing a correct face

(*M*= 867.86, *SD* = 281.49) than recognizing an incorrect face (*M* = 1047.36, *SD* = 372.97), $t(20) = -1.96$, $p = .064$.

Discussion

The graph plotting bias against manipulation condition (see Figure 2) follows a downward, step-like pattern and does not match any type of polynomial contrast. This is inconsistent with the CA model (Huttenlocher, et al., 1991) and the results from Experiment 1. Additionally, previous research examining the effect of time on the category bias demonstrates that bias increases over longer delay periods (Hund & Plumert, 2002; Sampaio & Wang, 2012). The reduction in bias across conditions in Experiment 2 violates basic principles of memory and likely reflects a statistical anomaly. The sample in Experiment 2 consisted of undergraduate psychology students who waited until the end of the quarter to fulfill their research credit requirement. The unusual data may reflect an aberrant sample; perhaps participant nine was the only one to admit they did not follow the instructions. Furthermore, trimming rates (i.e., the percentage of data values that had to be removed because they were outliers) were approximately twice as large as they were in experiment 1, which provides additional support for the aberrant sample conjecture.

In contrast to recall data, recognition data are consistent with the CA model; that is, the pattern of false alarms suggest that when participants error, they choose a face closer to the prototype. Additionally, and unlike the recall data, responses in the recognition data were dependent upon the manipulation condition viewed during the acquisition phase.

General Discussion

The present study found a systematic bias towards a prototypical eye location after a delay of 2000ms. With recall data in Experiment 1, the study possessed adequate statistical power to detect the category bias in the omnibus ANOVA, but it was not sufficient to detect a significant difference between moderately and highly distorted conditions. Recall data from Experiment 2 revealed no effect of eye position on bias; therefore, we cannot draw conclusions concerning the effect of time on category bias for recalled locations and whether schema atypical effects for recalled locations persist over longer delay intervals.

The results of Experiment 1 are consistent with the CA model (Huttenlocher et al., 1991) and provide a replication of research demonstrating the category bias in facial memory (Sampaio and Symons, 2013). Several, compatible explanations exist to explain our pattern of results. First, at the prototype, coarse-grain and fine-grain representations match each other; that is, the coarse-grain representation is the prototype and the encoded stimulus (i.e., the fine-grain representation) was presented at the prototype. Regardless of how participants weighted each representation, bias would remain extremely low. Second, participants placed progressively heavier weights on their coarse-grain representation as the stimulus moved away from the prototype.

Although our lack of statistical power prevented the identification of a significant effect of extreme distortion on bias reduction, examining possible explanations for the mean decrease in bias in the extreme conditions warrants consideration. Huttenlocher et al. (1991) demonstrated that when participants' attentional resources were depleted by completing a distracter task during the experiment, category bias increased; that is, as the fine-grain representation became more inexact, participants' relied more heavily on their coarse-grain representation. Although we manipulated degree of distortion, previous research examining the attention postulate of schema theory offers two explanations (Friedman, 1979; Johnston et al., 1990; Gordon, 2004).

Friedman (1979) and Gordon (2004) demonstrated that participants' focused their attention on schema atypical features in a scene. Although we specifically instructed our participants to remember eye location, any differences in the amount of time spent attending to eye position should have affected the weight participants placed on their fine-grain representation. If the same effect that occurred in the Friedman study and the Gordon study was operating in our study, participants should have spent comparatively more time observing eye location in the extreme conditions, which would have affected fine-grain inexactness and the degree of category bias. To examine this conjecture in more depth, future research could monitor participants' eye gaze.

A second explanation stems from the mismatch theory research examining novel pop out effects (Johnston et al. 1990; Johnston et al., 1993; Johnston et al., 1994). Specifically, novel stimuli may induce qualitative changes in processing. With familiar, schematic stimuli, top down, schema-driven processing dominates; however, novel stimuli result in a shift towards data-driven processing. Conceptually, mismatch theory is compatible with the CA model. When viewing prototypical or moderately distorted stimuli, schema-driven processing may dominate, resulting in a comparatively heavy weight, reflected by bias, being placed on the coarse-grain representation. However, in the extreme conditions, the processing change associated with the novel pop out effect may dominate, resulting in a significant shift in the weight placed on the fine-grain representation and a reduction in bias.

For the recognition task, the possibility exists that the subtlety of the horizontal eye movements in our stimuli created a just noticeable difference (JND) problem. Therefore, we should consider research examining people's threshold for detecting horizontal eye manipulations. When JND is defined as above chance accuracy, Haig (1984) demonstrated that his participants' JND was 1.75 pixels for inward manipulations and 2.53 pixels for outward manipulations. In Haig's study, 1.2 pixels equaled one minute of visual angle, which Graham (1965) notes nears human visual acuity limitations (as cited in Haig, 1984). When JND is defined as achieving greater than 75% recognition accuracy, Ge, Luo, Nishimura, and Lee (2003) observed that the JND for Chinese participants recognizing differences in the distance between horizontal eye manipulations of Chairman Mao's face exceed visual acuity limits (JND = 9.8 pixels for inward manipulations and 11.55 pixels for outward manipulations). Additionally, using the same criteria, Bredart and Devue (2006) found that the JND for participants detecting differences in eye width manipulations in their colleagues' faces were 7.2 pixels for inward manipulations and 8.7 pixels for outward manipulations. Ge et al. used Adobe Photoshop to manipulate eye width; when Bredart and Devue (2006) replicated Ge et al.'s research with a different sample and stimuli, they used GIMP with the same pixel manipulation, suggesting consistency in the pixel measurement tool between programs. Significant differences between samples, stimuli, experimental designs, and our lack of viewing distance data make inferences highly speculative. However, on average, the distance between each manipulation condition was 5 pixels in our study. The previously discussed research on JND thresholds indicate that visual acuity limitations may have affected our recognition data. To address JND concerns, future research could use stimuli with spatial manipulations within the boundaries of human visual acuity.

In addition to issues raised by visual acuity, field of vision limitations could have made it difficult for our participants to view both eyes using central, rather than peripheral, vision. This may have affected fine-grain inexactness, with fine-grain representations becoming more inexact in the outward manipulations. This conjecture is consistent with the observation that JND for outward manipulations exceed the JND for inward manipulations (Haig, 1984; Ge et al., 2003; Bredart & Devue, 2006). My failure to measure viewing distance prevented us from determining if the eyes on the outward manipulation faces fell within the 30 degrees of central vision (Spector, 1990). Despite this shortcoming, two findings in our study suggest that central field of vision limitations did not affect our results. First, both experiments failed to detect a significant difference in bias between inward and outward manipulations. Second, if central field of vision limitations increased fine-grain inexactness, manipulation condition eight should yielded the highest level of bias. Although the reduction in bias between manipulation conditions seven and eight was not statistically significant, testing for an increase in bias could not yield a significant result.

Although the literature testing the attention postulate of schema provides a sound theoretical argument for manipulating attention by varying schema consistency, future research could experiment with attentional manipulations. For example, researchers could use the distracter task employed by Huttenlocher (1991), which was found to moderate the category bias in memory for dots located within circles. Alternatively, researchers could manipulate the amount of time participants have to view the stimulus. With either manipulation, varying the magnitude of the attention manipulation (e.g., the difficulty of the distracter task or the length of viewing time) would not be methodologically difficult and would provide a useful elaboration on the effect of attention in moderating category bias. Specifically, a within-subjects experiment varying attention along a continuum could determine the point at which decreasing attentional resources yields a significant effect, as well as the trend in bias (i.e., linear, logarithmic, or exponential, etc.). In sum, alternative attentional manipulations and continuum manipulations would contribute a useful elaboration on the effect of attention in moderating category bias in moderating facial memory.

To better ascertain the effect of time on moderating the category bias in facial memory, manipulating time within-participants would decrease the likelihood of an aberrant sample comprising a study. Additionally, varying time along a continuum would yield the same benefits as it would for attention. Specifically, a continuum manipulation would determine the delay necessary to produce an effect, as well as the function (e.g., does bias increase in a linear, exponential, or logarithmic manner) the bias follows as time passes.

The accuracy of facial memory has profound implications in our legal system. If the category adjustment model operates while a witness works with a sketch artist or uses a computer program to select and place features, the suspect’s face may differ considerably from the reproduction. When choosing a face out of a lineup, an eyewitness may select a person with a more prototypical face, as opposed to the suspect.

Although a subtle bias in placing the location of the eyes may seem like minutia in terms of affecting the overall accuracy of a reproduction, the category bias in facial memory may apply to other spatial representations (e.g., the four-way relationship between the eyes, nose, and mouth). As the number of features affected by the category bias increases, the level of distortion in the reproduced face will increase. Consequently, future research elaborating on the category bias and feature relationships will serve a useful function in our criminal justice system.

Extending from the previously discussed practical implications, but moving away from spatial memory, future research could examine if a process conceptually related to the category bias occurs with featural processing. The Solso and McCarthy (1981) study provided evidence that people form a prototypical face by combining the model features of a face set. Additionally, Goldstein et al., (1977) postulated that, because of the same type of modal integration suggested by Solso and McCarthy, their participants committed false alarms with certain faces at a high frequency. Future research could first identify a prototypical facial feature in a population. Rich et al. (2008) used a morphing program to transform a facial expression of emotion from neutral to a strong emotion (e.g., rage). Researchers could then use the same morphing program to transform a prototypical feature into a schema atypical feature. Examining recognition accuracy at the prototype, in moderately distorted conditions, and in highly distorted conditions, as well as patterns in false alarms (i.e., do participants adjust responses towards the prototype until they reach the extreme condition) may identify a second process that affects the validity of eyewitness identification.

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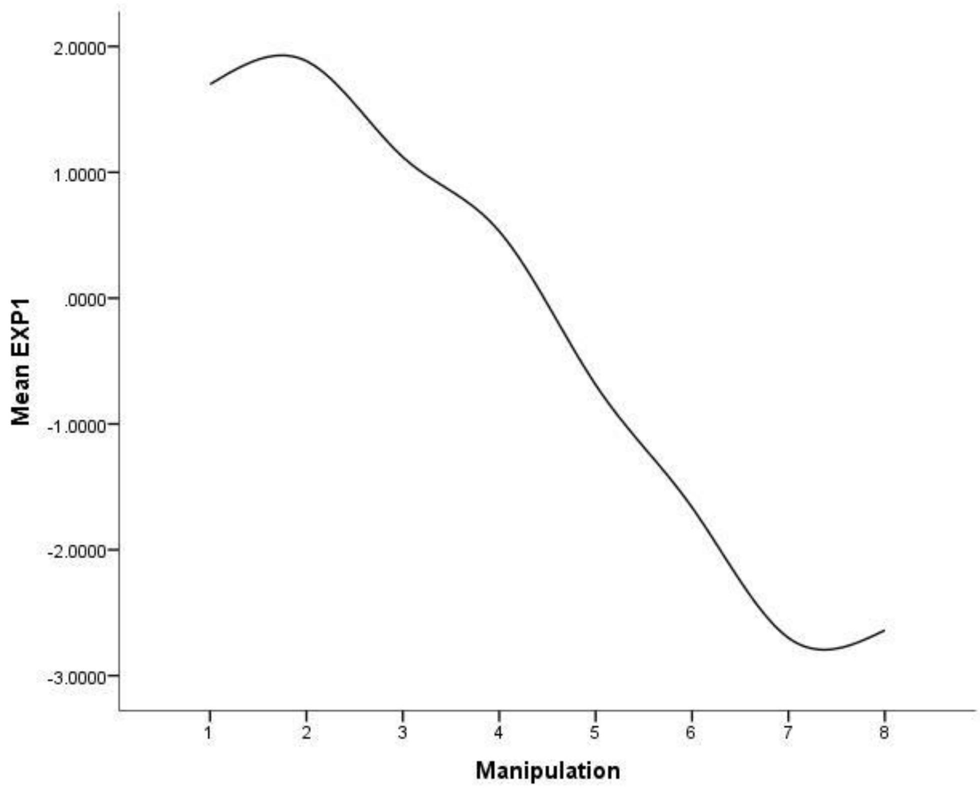


Figure 1. Bias plotted against manipulation condition for recall data in Experiment 1. On the x-axis, one denotes the condition where the eyes touch in the center of the face, and eight denotes the condition where the eyes are located at the outer edge of the face. A positive number on the y-axis indicates that participants adjusted their recalled responses outwards; a negative number on the y-axis indicates that participants adjusted their responses inwards.

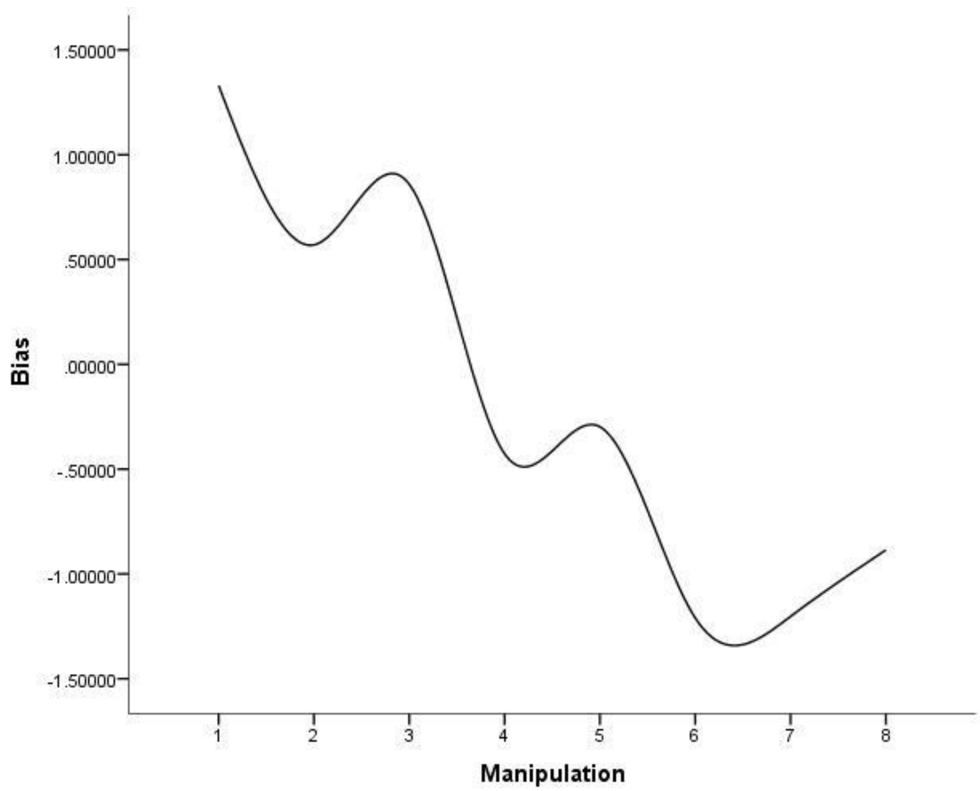


Figure 2. Mean bias plotted against manipulation condition in Experiment 2. On the x-axis, one denotes the condition where the eyes touch in the center of the face, and eight denotes the condition where the eyes are located at the outer edge of the face. A positive number on the y-axis indicates that participants adjusted their recalled responses outwards; a negative number on the y-axis indicates that participants adjusted their responses inwards.

Table 1

Recognition Accuracy Experiment 1

	Response							
Input Manipulation	1	2	3	4	5	6	7	8
1	62.6%	28.3%	4.4%	2.8%	.9%	.3%	.6%	0%
2	5.0%	57.8%	28.1%	4.7%	1.6%	1.9%	.9%	0%
3	0%	9.4%	58.8%	21.9%	6.3%	2.8%	.3%	.6%
4	.6%	1.9%	22.0%	50.0%	20.4%	4.4%	.6%	0%
5	0%	1.3%	6.3%	25.7%	45.5%	18.5%	2.5%	.3%
6	.3%	.3%	2.8%	7.5%	28.8%	48.9%	11.0%	.3%
7	.3%	0%	1.9%	2.8%	11.3%	40.8%	38.6%	4.4%
8	.9%	.6%	.6%	2.2%	3.1%	13.5%	54.5%	24.5%

Note. Table one displays responses by manipulation condition. Input manipulation is displayed on the vertical column. Responses are listed on the horizontal column. Percentages denote the percentage of participants who selected each face at recognition. When the input matches the response, participants chose the correct face. When the input does not match the response, participants committed a false alarm.

Table 2

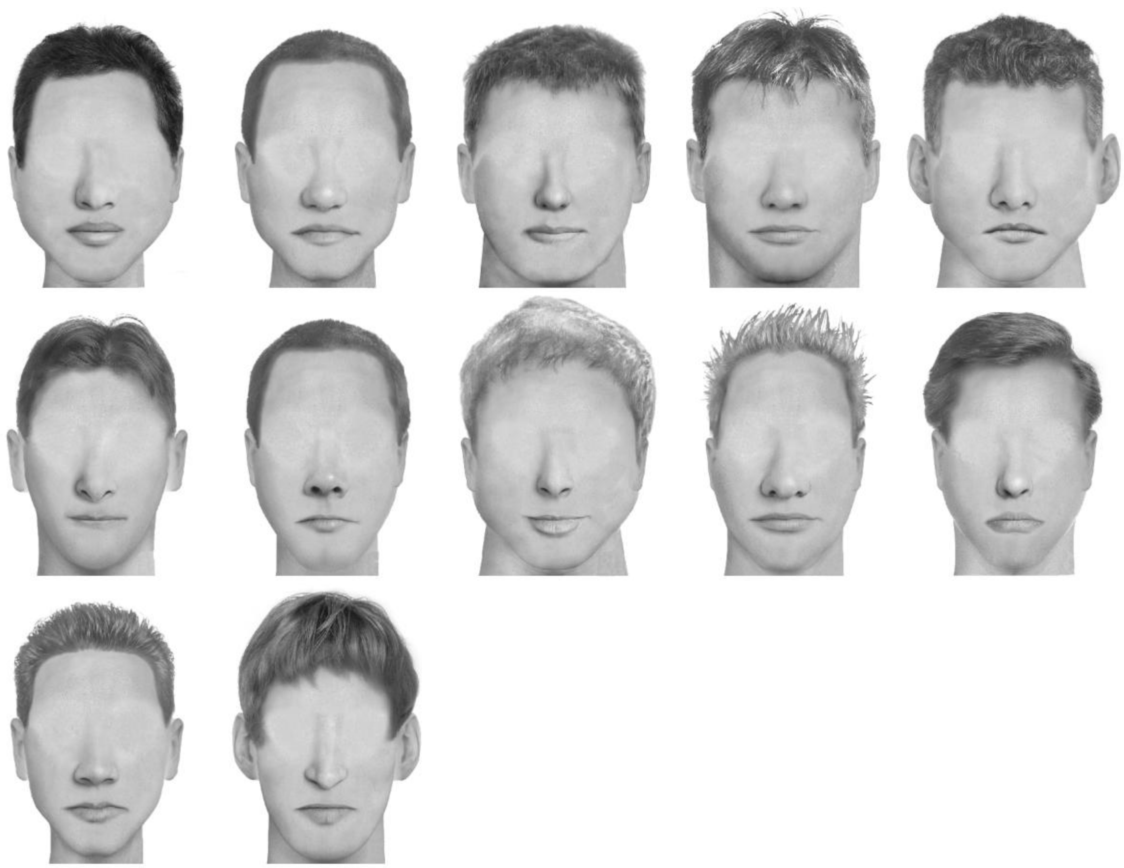
Recognition Accuracy Experiment 2

Input Manipulation	Response							
	1	2	3	4	5	6	7	8
1	69.1%	25.5%	1.8%	2.7%	0%	.9%	0%	0%
2	1.8%	60.0%	32.7%	1.8%	1.8%	1.8%	0%	0%
3	0%	2.7%	63.6%	30.0%	3.6%	0%	0%	0%
4	0%	0%	10.9%	60.9%	20.0%	7.3%	.9%	0%
5	0%	1.8%	2.7%	26.4%	53.6%	15.5%	0%	0%
6	0%	0%	2.7%	3.6%	39.1%	47.3%	7.3%	0%
7	0%	1.8%	0%	1.8%	10.0%	48.2%	36.4%	1.8%
8	0%	0%	.9%	1.8%	.9%	15.5%	53.6%	27.3%

Note. Table two displays responses by manipulation condition. Input manipulation is displayed on the vertical column. Responses are listed on the horizontal column. Percentages denote the percentage of participants who selected each face at recognition. When the input matches the response, participants chose the correct face. When the input does not match the response, participants committed a false alarm.

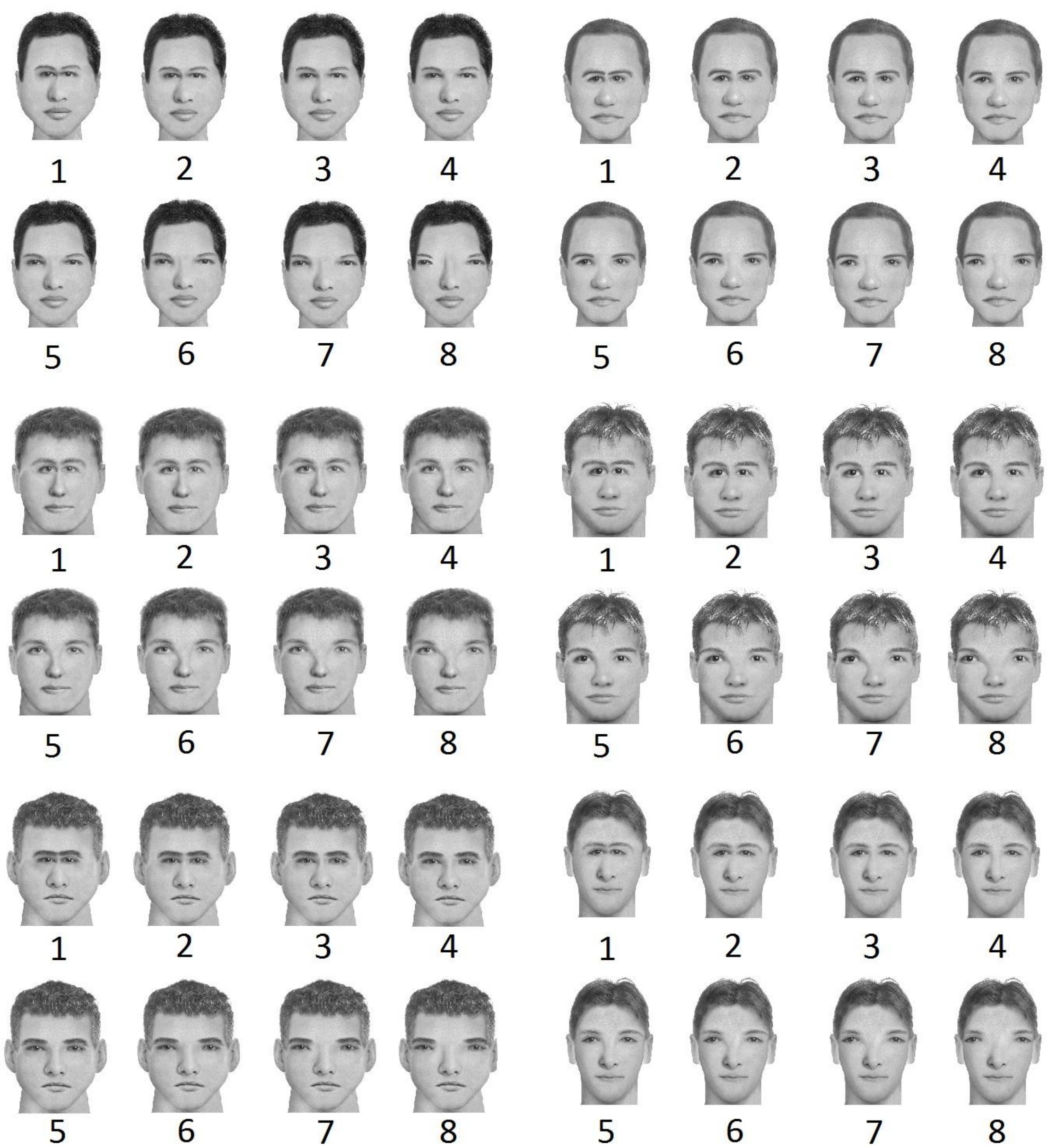
Appendix A

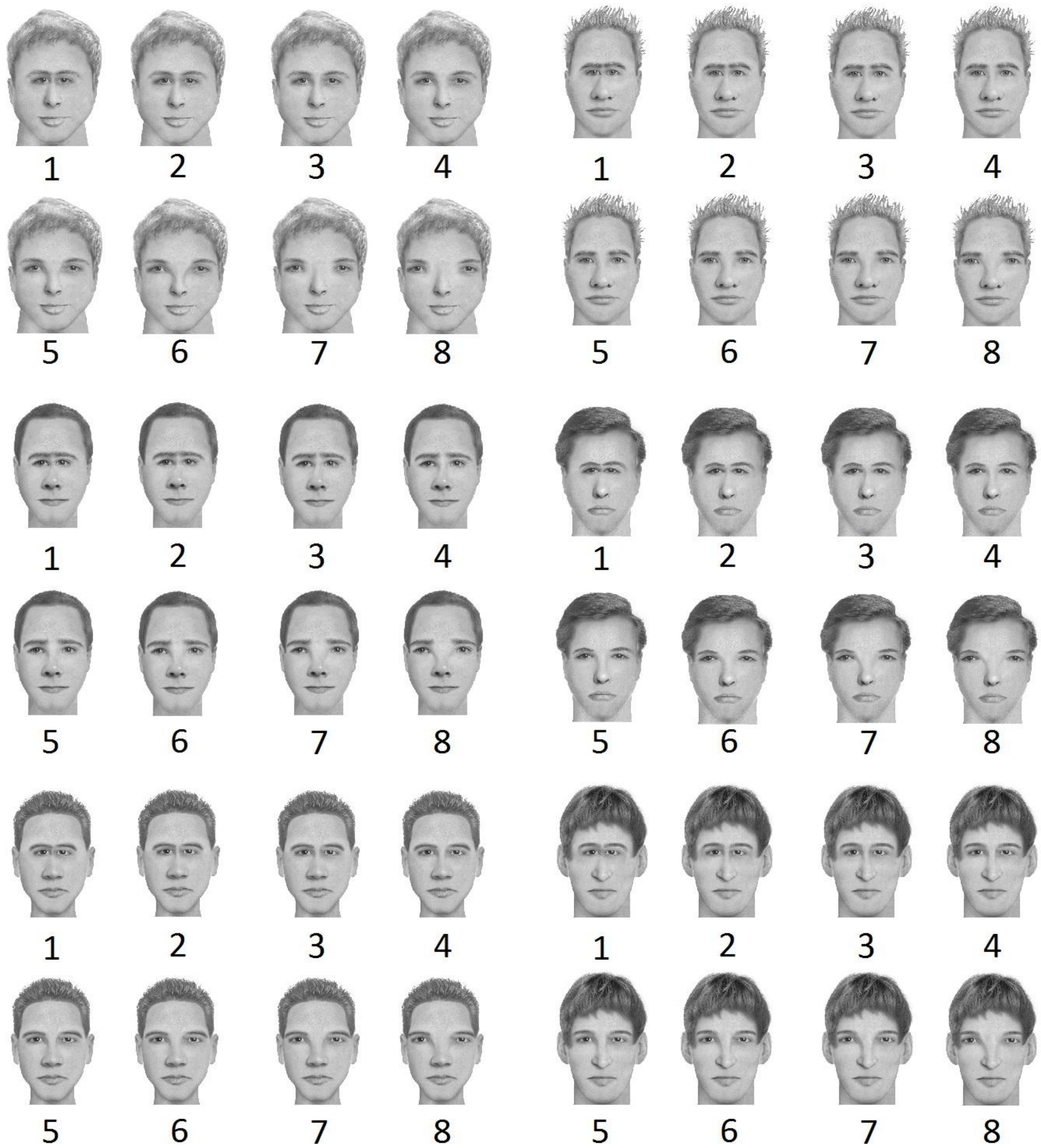
TEST STIMULI FOR RECALL TASK AND PROTOTYPE IDENTIFICATION STAGE



Appendix B

ACQUISTION STIMULI FOR RECALL TASK AND ACQUISITION AND TEST STIMULI FOR RECOGNITION TEST




1 2 3 4 1 2 3 4
5 6 7 8 5 6 7 8
1 2 3 4 1 2 3 4
5 6 7 8 5 6 7 8
1 2 3 4 1 2 3 4
5 6 7 8 5 6 7 8