The Influence of Prior Knowledge on Recall for Height

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Abstract

Recall for the height of a person can be influenced not only by general knowledge about heights of people, but also by specific knowledge about the height of men and women. We assess the relative contribution of this type of prior knowledge on reconstructive memory. We present an empirical study testing recall for the height of females, males and ambiguous silhouettes. Our results suggest not only that prior knowledge can improve average recall, but also that knowledge can come from multiple levels of abstraction such as gender and the overall height of people.

Keywords: Prior knowledge; Episodic Memory; Reconstructive Memory; Gender Differences

Introduction

Imagine walking down a street when you see a man and a woman snatch somebody's purse. As a witness, you are asked by the police to recall the physical characteristics of the suspect, including their height. To reconstruct the event, you may use not only the episodic information related to the specific incident, but also the general knowledge you have about peoples' heights. You might infer that the woman involved was about 5'4'', not because you remember her height exactly, but because you know that this is the average height of women in general. When asked about the male, you might infer that he was about 5'8'' based on what you know about the average height of men. This scenario illustrates that many aspects of our experiences do not have to be explicitly remembered, but can be inferred based on our knowledge of the regularity of our environment.

Across societies, there are widely held expectations drawn from natural observations and experiences that discernable differences exist between males and females. These discrepancies may be physiological, such as height (e.g., Biernat, 1993), or behavioral, including cognitive patterns and social roles (e.g., Eagly & Steffen, 1984). Because of the abundance of salient dissimilarities between males and females, people develop strong-held beliefs about gender characteristics. As evidence of this, social biases can often affect decisions when people are given a situation to judge between genders, (Nelson, Biernat & Manis, 1990). Our perceptions and memories are influenced by our awareness of the true distributions we observe in nature (Konkle & Oliva, 2007). Based on real-life distributions, people unintentionally depend on knowledge in the form of biases and stereotypes to draw conclusions and make estimations. Applying this to the earlier example, it is expected that knowing the gender of the crime suspect before making the estimate should have an impact in estimating their height. Yet, the question is: Would it help yield a more accurate estimate by providing additional relevant information, or be a disadvantage by applying a stereotype?

The plan for the current paper is to first review theoretical accounts of the influences of prior knowledge on memory in the literature. We will then present an experimental paradigm and an empirical study where we measure people's prior knowledge and then test the interactions of prior knowledge and episodic memory in recall of the heights of people. Lastly, we will illustrate why this is important to the understanding of reconstructive memory.

Effects of Prior Knowledge on Memory

Much memory research has focused on the negative effects of prior knowledge. For example, when recalling lists of semantically related words, prior knowlehallelujahdge not only introduces recall errors but also elicits false memories (Roediger & McDermott, 1995). Conceptually themed lists can "lure" participants into recalling words with semantic associations to the theme, which were not on the actual studied lists. Many participants who retrieved these false memories also reported high levels of confidence that the false alarms were on the previously displayed word lists. This suggests that memory is highly malleable and can be altered unconsciously. Memory is especially prone to intrusions when certain expectations are heightened. For example, participants might falsely recall books from an office where no books are present, because most offices are expected to contain books (Brewer and Treyens, 1981). The general conclusion has been that expectations and prior knowledge can lead to systematic errors in recall.

On the other hand, prior knowledge can also be beneficial to memory. The availability of meaningful information can improve recall for abstract concepts (Bartlett, 1932). When memory is noisy and incomplete, prior knowledge can also improve recall. Hemmer and Steyvers (2008) showed that reconstruction from memory was better for objects for which participants had pre-experimental prior knowledge. They compared recall for naturalistic stimuli (fruits and vegetables) and unfamiliar stimuli (artificial shapes). They found that recall for naturalistic stimuli was on average more accurate than for shapes, even when participants did not remember studying the objects. These findings were consistent with those of Huttenlocher et al.'s (1991), who found that prior knowledge improves average recalls. Konkle and Oliva (2007) also showed that memory for object size is biased toward the normative size of objects consistent with their real-world size.

Prior knowledge might also influence recall at various levels of abstraction. Hemmer and Steyvers (2008) found that prior knowledge had different effects at multiple levels of abstraction, and proposed that the influences are hierarchically structured. For instance, objects with limited categorical information (artificial shapes) were biased towards the mean of the superordinate distribution, whereas objects with clear categorical information (fruits and vegetables) were biased towards their specific object distributions. Similarly, prior knowledge for height might exist not only for the general height of people, but also at a more fine-grained level based on gender (females on average are shorter than males). A hierarchical influence of prior knowledge would make two clear predictions about the effect of prior knowledge. First, that there will be an overall regression to the mean, where people at heights below the mean population height are overestimated and people at heights above the mean population height are underestimated (See Figure 1, Panel A). The second, and critical, prediction is that when two people, a short male and a tall female, are studied at the exact same height, recall will be biased towards the genders specific height distribution. The tall female will be underestimated towards the mean of the female height and the short male will be overestimated towards the mean of male height. In other words, prior knowledge will differentially affect the memory of two people originally presented at the same height. Figure 1, Panel B illustrates this effect. Thus, having prior knowledge at a finer-grained level might contribute to further improvements in average recall over general level knowledge.

Current Study

In the present study we seek to further explore the interactions between prior knowledge and recall for naturalistic stimuli. Huttenlocher et al. (1991) trained participants on artificial stimuli distributions for dots and circles - stimuli that were unrepresentative and unnatural outside of the laboratory setting. While Hemmer and Steyvers (2008) focused on more naturalistic stimuli, the sizes of fruits and vegetables can vary quite broadly across cultures and time. For instance, while watermelons may only be experienced as round in the United States, they are available in square and even heart-shapes in other countries. While there was a large degree of agreement between participants in the normed Hemmer and Steyvers size judgments it is possible that semantic inconsistencies in the stimuli could have affected the results.

We investigate the influence of prior knowledge in height estimation of males and females, examining how the biases change performance in judgment tasks. We focus on the manipulation of stimuli pertaining to the height of males and females because a) there is a prominent difference in mean height between genders; b) there is an objective scale for measurement; c) the stereotype of correlation between certain height ranges and gender is both accurate and universal; d) the stereotype is drawn from real-world distributions and is consistent in nature. We believe that the current approach encompasses a useful strategy for evaluating the effect of prior knowledge on reconstructive memory for naturalistic stimuli.

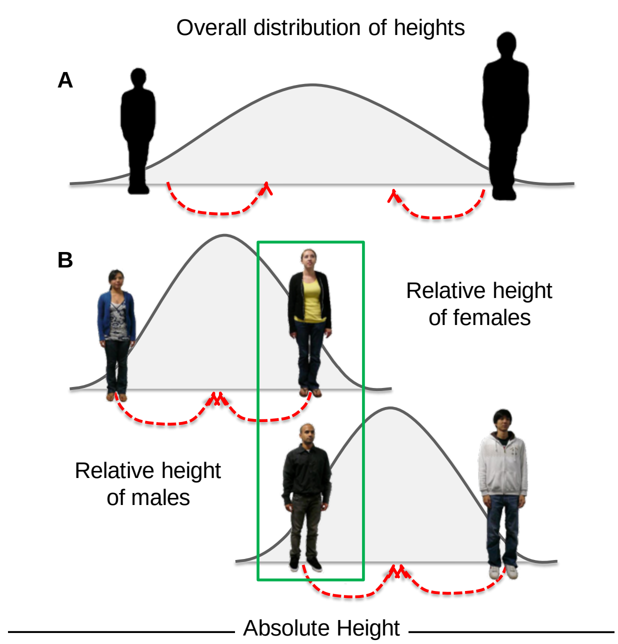

Figure 1. Predicted biases in recall as a function of A) limited gender information, and B) clear gender information for females and males.

Experiment

Methods

Participants Participants were students at the University of California, Irvine. Course credit was given as compensation after their completion of the experiment. There were 22 participants in the norming phase and 22 in the memory experiment. Participants of the norming phase were not involved in the memory experiment.

Stimuli To develop our stimuli we photographed 200 male and female students at the University of California, Irvine. The people in the images were requires to stand up straight, and have their hands to the side, and maintain a neutral expression. Women were required to have their hair up. The height, in whole inches, was recorded for each individual.

To ensure that our stimuli accurately reflected a sample of the true population, we compared the distribution of stimuli height to height statistics obtained from the Center for Disease Control. The mean height in the US population over age 20 is 63.8 inches for females and 69.4 inches for males (McDowell et al. 2008). In our sample the mean height was 63.9 inches for females and 68.9 inches for males. Our sample ranged in height from 58–72 inches for females and from 64-76 inches for males. Figure 2 shows the cumulative density function for the stimuli and the CDC data.

The results show that our stimuli were representative of the population. We selected 48 images to be used in the two experiments as our 'unmasked' images. It is important to note that the 24 images for each gender were selected such that they were representative of the height proportions in the population based on the CDC data.

The purpose of the unmasked stimuli was that it retained all aspects of the figure, revealing prior knowledge of gender (For example stimuli see Figure 3, panel A and B).

We also created a category of 'masked' images to be used as a comparison in the memory study. To produce the masked stimuli, we filled the interiors of the 48 unmasked stimuli with a black color. The masked st-imuli retained only the height and human figure information, which strongly limits the accessibility of gender information (See Figure 3 panel C for a sample of the masked stimuli). A ratings panel evaluated the masked images to ensure that the stimuli were adequately ambiguous and that the physical characteristics were not predictive of height judgments. We presented the masked images on the right side of the computer screen. An image of a door was displayed as a comparison image (See Figure 2 panel D). The ten raters were independently asked the following question for each image: "What do you think the gender of this

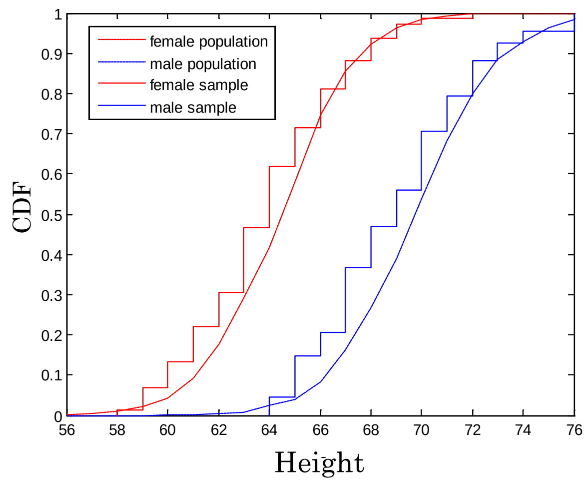

Figure 2: Cumulative density functions for the population and stimuli by gender. Red indicates female, blue indicates male. Dashed lines represent the true population, stair steps represent stimuli.

person is?" Based on these ratings we selected 24 images, 12 of each gender, that were most ambiguous and most representative of the true height distribution to use in our memory experiment. All unmasked stimuli measured 456 x 1229 pixels. All masked stimuli measured 285 x 768 pixels.

Norming Phase To assess people's prior knowledge for the heights of females, males and ambiguous figures, we asked people to make height judgments for all 72 stimuli. We presented the stimuli one at a time on the right side of the computer screen. An image of a door was displayed as a comparison image (See Figure 2, D). Prior to the experiment, the participants were shown the

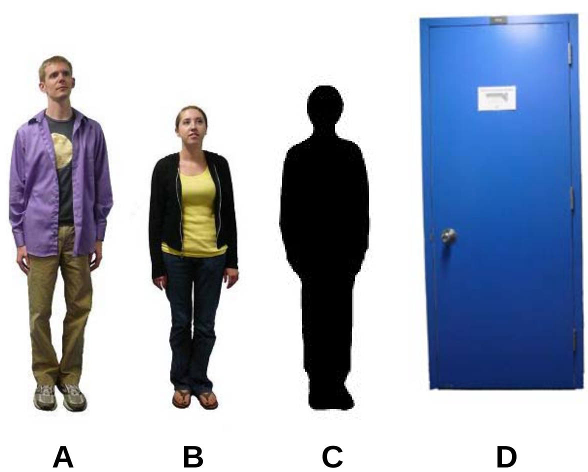

Figure 3: Stimulus examples from the norming and memory experiment. A) an unmasked male, B) an unmasked female, C) an ambiguous masked figure, and D) a reference image of a door.

actual door that was used as a reference in the task. They were asked the following question for each image: "What do you think is the true height of this person, compared to the door on the left?" They responded by using a slider to resize the image of the person. Trials were randomized across and within blocks.

Memory experiment We implemented a continuous recall paradigm where the study and test phases are randomly intertwined. The images were blocked by category (unmasked and masked). There were 2 blocks, comprised of a total of 72 images. Block 1 was comprised of 48 unmasked stimuli (24 male and 24 female) and Block 2 consisted of 24 masked stimuli. Randomization was ensured between and within each of the blocks. The comparison image of the door that was used in Experiment 1 remained fixed on the left side of the screen at all times. Each study image was presented for 2 seconds on the right side of the screen and was presented at the true height relative to the door. Upon presentation, the initial size of the test image was set at random. Participants were asked the following question, "What was the height of this person, compared to the door on the left, when you saw them at study? If you are not sure, make a best guess." To reconstruct the studied size, the participants used the computer mouse to move a slider on the right edge of the screen. Once they had scaled the figure to the size they recalled from study, they clicked on a button labeled "OK" and proceeded to the next trial until the experiment ended.

Results

Norming Phase All of our measurements will be given in centimeter (cm) units. To ensure that the female figures in the masked images were not judged to be shorter than the males masked images we evaluated the mean estimated height judgments. A paired t-test showed that the estimated means for females (150.5 cm) were not smaller than the estimated means for males (147.78 cm), p=0.89. In fact the female figures were judged to be on average taller than the male figures. This might have been a result of our effort to remove female gender characteristics. This did not affect the results of the memory study, however.

We also tested the correlation between the estimated and true heights for the gender images. There was a small, but significant correlation between the estimated and true height for females (r=0.24) and between the estimated and true height for males (r=0.19).

Memory experiment To investigate the effect of prior knowledge on recall for the height of males, females and ambiguous masked figures, we measured recall error as the difference between the recalled size and the studied size.

Figure 4 shows the recall errors as a function of absolute study size for each category – female, male and masked figures. The lines in the figure have two important aspects: slope and intercept. We first evaluated the bias toward the mean height. A negative slope indicates a bias to the center of the range of heights, such that short people are overestimated and tall people are underestimated.

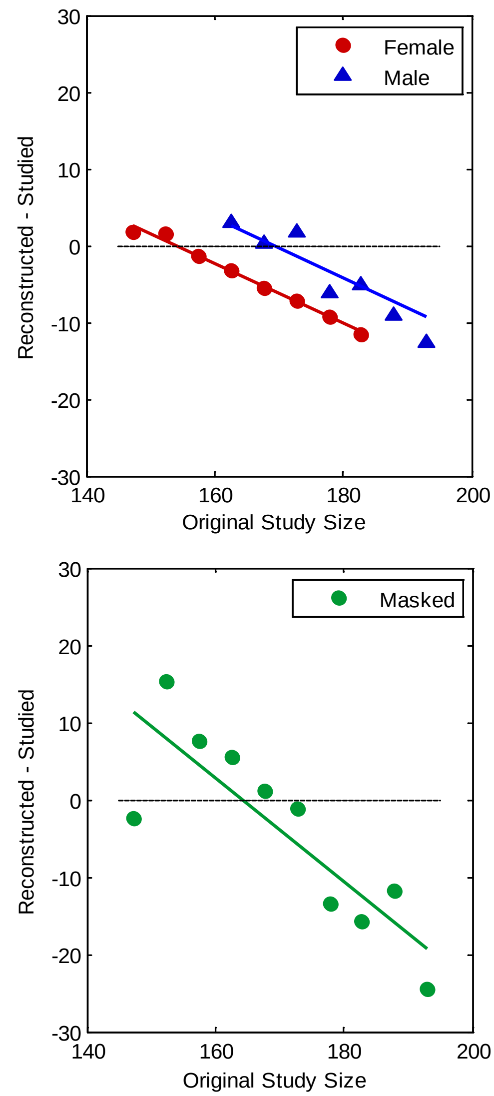

Figure 4: Recall bias as a function of original study size. The results are grouped by female, male and masked stimuli. Circles and triangles denote the experimental data. Lines show the linear regression model fits.

The observed pattern of correction toward the category center as indicated by negative slopes for all categories supports the prediction that recall is biased toward the mean. The slope for each category was significantly smaller than zero (female, t (21) = -6.775, p <.001;

Table 2: Mean slopes and intercepts by category

	Females		Males		Masked	
	M	SD	M	SD	M	SD
Slopes	-0.39	0.28	-0.39	0.27	-0.67	0.30
Intercepts	51.81	4.08	56.95	3.74	110.27	6.89

male, t (24) = -6.678, p < .001; masked, t (24) = -10.823, p < .001).

We then evaluated the effect of having more fine-grained prior knowledge. The difference between intercepts tests our key prediction that people studied at the same absolute study size can be differentially biased, depending on prior knowledge about height at the gender level. An intercept difference indicates a bias to the center of the height range for each gender, such that people that are presented at a size that is small relative to that gender's height distribution lead to a greater overestimation error than do people presented at a relatively large size. To assess the influence of gender-level prior knowledge, a linear regression model was fitted separately for each subject. The regression model contained three parameters for each category: two intercept parameters, corresponding to male and female, and a single slope parameter (see Figure 4 for fits of this regression model). A separate regression model was fitted to the masked category with a single intercept parameter. Table 2 shows the mean estimated slopes and intercepts across categories.

The results show that the intercept for female was smaller than that for male. This difference in intercepts by relative study size supports the prediction of gender-level prior effects. A repeated measures ANOVA with three levels (female, male and masked) found a significant effect of category [F(2,42)=698.56, p< .001]. Bonferroni adjusted contrasts showed a significant difference between female and male intercepts (p < .001) and between masked and both female (p < .001) and male (p < .001) intercepts. These differences are consistent with an influence of prior knowledge at a more fine grained level of knowledge. These differences in intercepts confirm the prediction that when a male and a female are studied at the same height, reconstruction is differentially biased depending on their relative height.

We also determined the relationship between semantic and episodic (*prior knowledge phase* or *memory experiment)* memory performance. In this analysis, recall error was assessed by mean absolute deviation, which measures the absolute deviations between the recalled and studied height for the memory data, and the absolute deviation between the estimated and true height for the prior knowledge data. Larger values indicate worse performance. Figure 5 shows the mean absolute deviation by category and experiment type. A 2 (experiment type) x 3 (category) repeated measures ANOVA was performed. There was a significant main effect of experiment type [F(1,42) = 759.749, p < .001]. Recall error was significantly lower for memory responses than for prior knowledge responses. There was a significant main effect of category [F(2,84) = 58.164, p < .001]. Bonferroni adjusted contrasts showed that recall error was greater for masked figures than for female [p < .001] and for male [p < .001]. There was no significant difference between the recall errors for female and for male [p=*1.000*]. The worst performance was observed for masked figure in the prior knowledge experiment. In this condition, performance was similar to chance, as measured by the mean estimated height from the masked condition (indicated in Figure 5 by the dotted line). This can be thought of as the mean of the psychological distribution of heights from which people are sampling in their head, rather than the absolute mean from the stimuli. This is the equivalent of the participants always guessing with the mean estimated height. There was no significant interaction effect between experiment type and category [F(2,84) = 2.003, p = .14]. However, a trend was observed such that in the prior knowledge condition people performed better in both the female and male category than in the masked category.

As noted earlier there was a significant correlation between the estimated and the true height for both the female and male figures. This suggests that a priori, people can give an estimate of the true height of a person based only on the configural properties of the person. However, the accuracy of such an estimate is not very high and importantly, this guessing factor cannot explain the performance differences between the memory and norming experiment. Clearly, participants are relying on some memory of the individual in their height estimate.

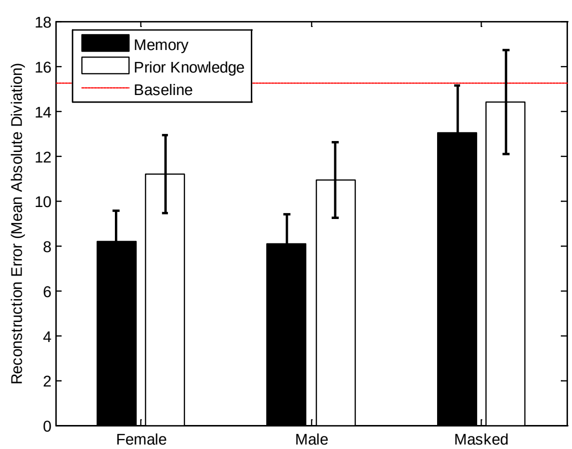

Figure 5: Recall error measured by mean absolute deviation. The error is grouped by category and study type. The baseline error is equivalent to responses based on the mean of the overall height distribution. Error bars indicate standard errors of the means.

Discussion

In the current study we investigated the influence of prior knowledge of gender differences in height on recall for height of specific individuals. We have shown that episodic memory is influenced by general knowledge about height such that short people are overestimated and tall people are underestimated. Furthermore, we have shown that the influence of prior knowledge is hierarchical, such that more fine-grained information about the height based on gender leads to biases toward the average height of men and women independent of the absolute study size. Recalled height for a relatively short male (shorter than the mean height for men) will be overestimated while recalled height for a relatively tall female (taller than the mean height for women) will be underestimated.

Our experimental design precludes the possibility that these results are due to sequential effects, slider effects or edge effects. While these effects might still act on the data they cannot be the sole explanation of our findings. There are three possible ways that people might reconstruct the studies height: 1) they might recall the height from memory; 2) They might use prior knowledge to reconstruct the height of the person; 3) they might guess at the height using some artifact information inherent in the stimulus such as configural features that might indicate if a person is short or tall. While our analysis of the prior expectations of the heights of the male and female stimuli showed that people might be able to guess the true height of a person based on some configural information, this cannot by itself explain our data because of the difference in performance between the memory and prior knowledge experiments. Overall, our results are consistent with the view that prior knowledge influences recall at multiple levels of abstraction.

We also show that having gender-level knowledge improves recall performance compared to ambiguous stimuli with a broader level of prior knowledge. Furthermore, while having episodic information leads to the best performance, there is less error in size estimation for gendered stimuli than for ambiguous stimuli. When making height estimates about ambiguous stimuli the best strategy a participant could employ is to guess with the overall average height of people. However, when gender information is available participants can guess with knowledge about the height at a more fine-grained level of gender. The results obtained from our experiment suggest that prior knowledge can be beneficial towards the accuracy of our memory.

As our findings are applied to the scenario discussed at the beginning of this paper, knowing the gender of the crime suspect prior to making a height approximation would help yield a more accurate estimate. When more information is given about something to be remembered, the method of reconstruction or estimation shifts towards a more fine-grained process. Using prior knowledge can be an efficient strategy to reconstruct episodic memories, especially if those memories are noisy and incomplete.

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