DO THE EFFECTS OF LANGUAGE ON PERCEPTION DEPEND ON HEIGHT?

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Abstract

When you read stories or scenarios, does it cause you to imagine what is being described? If so, does that imagery look similar across individuals, or does it depend on the physical and perceptual experiences a person has had? This study tests whether an individual's height affects how they understand the language that they read. The participants in this study were separated into two between-subjects conditions. Half the participants read a story that could be interpreted differently by tall and short people (a story about hanging coats on a rod), and the other half of the participants read a story that was neutral with respect to the height of the participant (taking payments at a register). Participants were then followed up by an ambiguous bird image that could be interpreted as facing upward or downward, and they had to interpret it based on where they thought the beak was located on the image. Participants also provided their height so that we could test whether height predicted the direction in which understanding language affected perception. The results of this study showed that height did play a factor in how people interpreted the facing direction of the bird after reading the height-dependent story, but not after reading the height-independent story. However, these results were noisy, so more work is needed to better understand the role that perceptual experience plays in language comprehension.

Do The Effects of Language on Perception Depend on Height?

When we use and understand spatial language, are the meanings of words similar across speakers of the same language? Or do people who experience space differently in their everyday lives also form different meanings from language? Individuals have different perceptual systems. For example, some individuals have two cone types instead of three, and this affects how they see colors. Height is another variable that affects people's perspectives of the world. People of different heights see the world from different angles and vantage points. Therefore, it might be that when people with different bodies are asked to imagine the color of the sky or the top of their refrigerator, they have different mental imagery that corresponds with the types of cones they have or their height. For example, a person who is short might have more upward spatial information in their mental image of the top of a refrigerator compared to a person who is short. It could be that over time, systematic differences in mental imagery get associated with word meanings so that the *word* refrigerator starts to have more of an 'upward' meaning for short people than for tall people. The present study is designed to examine whether a person's height shapes the spatial meanings of words in this way.

Embodied cognition is the theory that the body's role in brain function is not just to support the brain's existence, but that our cognitive abilities and our knowledge about the world are affected by the body (Shapiro, 2010). This involves sensory and motor systems that are seen to be fundamentally integrated with cognitive processing according to the embodied view. This study tests the embodied cognition theory by asking whether people with different bodies develop different meaning systems.

Previous work demonstrated that imagining stripes at a particular orientation can influence visual consciousness (Pearson et al., 2008). According to the study, people's perception of gratings of different colors and orientations during a binocular rivalry task is influenced by the grating that was stable in the previous trial. If people saw a green horizontal grating on one trial, they were more likely to see that on the next one. However, mental imagery of the grating they did not perceive disrupts this effect, and mental imagery of the grating they did perceive strengthens it. Therefore, mental imagery influences processing at the very early stages of visual perception.

Mental representations contain more information than we are initially conscious of, and we can re-inspect those images to find additional information (Thompson et al., 2008). According to this article, judgments about non-obvious properties of letters were similar when people could view the letters they were judging and when people just imagined them and made judgments based on the mental image only. The terms *implicit* and *explicit* were conducted under two different categories of response time and error rate and with that, the results showed how with imagery and perception there was always an upward slope. This proved how the different effects of the visual complexity either influenced both or had no effect at all where the two never correlated with each other. In this study, the participants used mental imagery to understand what they were interpreting. Experiments like this prove how our human capabilities work in miraculous ways when dealing with object perception and mental imagery.

To what extent does understanding language automatically cause people to form mental images? Lupyan et al. (2020) review multiple findings showing that processing language can influence perception at all levels of visual processing. However, other theorists have argued that many of these types of effects are confounded or are tangential to the important parts of visual processing (Firestone & Scholl, 2016; & Pylyshyn, 2002). That said, language processing needs to be able to influence visual perception in real-time (Dumitru et al., 2013), so there is reason to expect that these representations can shape each other. The different perceptions of the images given in this study, prove how images allow us to use our visual perception that differentiates spatial and depictive settings. With this, we find how mental imagery does not correspond with these two because of how we function and how our brains take in the image given (Pylyshyn, 2002). Many studies like this one, show how what one sees is not what the other sees, and that can cause a lot of mixed results that leave one in question.

In fact, mental imagery that comes from processing language can interfere with visual perception when the two-take place in the same part of visual space (Bergen et al., 2010). In this study, participants listened to spatial sentences (e.g., “The ground / roof shook”). At the same time, they had to judge whether an object on the screen was a circle or square. When the sentence had an upward meaning, people were slower to make the visual judgment if the object appeared above fixation. Generally, if the object and sentence competed for the same part of the visual space, processing was impaired. This suggests that language and perception compete for the same resources. In this study, there was an influence on language involving mental imagery and with that, it helped understand the certain sentences that were given to the participants and allowed them to be manipulated in a way involving these objects' space (Bergen et al., 2010). The process of this study allowed for language comprehension and or motion to be differentiated between different participants and that allowed the researchers to understand the different perceptions given.

Previous work has shown that simply reading a story, without mental imagery given, can cause people to form spontaneous mental images (Dils & Boroditsky, 2010). In this study, participants read either a downward story or an upward story. After the participants read the stories, they saw an ambiguous image on the screen that could be seen as an upward-facing bird or a downward-facing bird (see Figure 1). Participants were asked to draw a worm in the bird's beak if they did it on paper (or click on the beak in an electronic version of the task). Participants' responses were coded as congruent with the story if they clicked on the beak facing the same direction as the motion in the story, and incongruent if they clicked on the beak facing the opposite direction. After reading a story describing visual motion, people were more likely to view the bird as facing the same direction as the story. This is the same effect that viewing real visual motion has on the perception of the ambiguous image. The effect goes away when you're reading about abstract motion (like rising and falling stock prices). When people understand language, they are engaging in visual imagery enough to change what they see in the world.

If language comprehension does involve spontaneous mental imagery, do people with a different perception and action systems imagine different things when they understand language? One example of how people with different physical abilities understand language differently comes from Landau and Gleitman (1985). They point out that, typically, the blind child has a different learning perspective because of not being able to see compared to sighted children. This creates a difficulty because the way they learn a language would be significantly different from a sighted child. Landau and Gleitman wanted to see if blind children could interpret language the same way as a sighted child would. They showed that the meaning of sighted verbs, like *look* and *see*, have coherent meanings in blind children, but the meanings are importantly different from those in sighted children. The sighted child's response to the phrase "look up" was to look up even when they were blindfolded and did not use any other movement in response to the action given. The blind child's response to the phrase "look up" was to physically put their hands up and not move their eyes or head at all to perform the requested action. This shows how language is interpreted by different individuals in body-specific ways depending on their capabilities. In sighted children, looking means moving your *eyes* in the right direction. In blind children, look means moving your *hands* in the right direction. Words have different meanings for language use based on the different gestures people typically use.

In the article, by Shepard and Cooper (1992), there are results showing how our representations of colors depend on people's color perception abilities. In this study, participants were given pairs of color words and asked to provide a similarity rating on a scale from 1-7. Similarity ratings were analyzed for the underlying factors that produced them, and the results of this analysis revealed that sighted people represent color as a wheel. Interestingly, blind people also represented color as somewhat of a wheel, but their color wheel collapsed in the middle because some color pairs were represented as more similar to each other than they were in sighted people. Therefore, both blind and sighted people have complex, structured representations of color, but these representations are different in people with different bodies.

Not only is there evidence that people with different visual systems represent visual information differently, but previous work has also shown that you can change visual representations by virtually changing the body (Iriki et al., 2001). In this study, monkeys were placed in an apparatus where they couldn't see their hands physically in front of them. Instead, they only had live videos of the hands-on monitor. The researchers manipulated the size of the hands relative to the objects the monkey was grasping and showed that the receptive fields of neurons representing the space around the monkey grew and shrunk according to the size of the hands. This suggests that our body representations affect how monkeys represent space.

Overview of the Present Study

Previous research has not fully addressed whether the details of mental imagery are similar across people or specific to the physical characteristics of each individual person, particularly for the meanings of non-visual words as well as for physical variation within the normal range. Therefore, this study is designed to test whether a person's height shapes the type of mental imagery they produce when they read a story. Participants read a story that either described hanging coats on a coat rack (experimental condition) or sitting at a counter and accepting payments from customers (control condition). The experimental story is expected to produce different types of mental imagery in short and tall people. For short people, hanging coats require an upward arm movement, and for tall people, it requires a downward arm movement. It is hypothesized that reading this story will cause people to perceive the ambiguous goose/hawk image based on their perspective of their own height. Tall people should see a downward-facing bird, and short people should see an upward-facing bird. Reading the control story should not produce imagery in any consistent direction and should not influence the way people interpret the ambiguous bird image.

Method

Participants

In this study, 800 participants were recruited to participate. Participants were collected through Mechanical Turk and Cloud Research. The participants were compensated at the rate of the U.S. minimum wage of $7.25, prorated for the length of the experiment ($0.60). Our participants were of many ethnic backgrounds such as White, Black, Native American / Asian / Pacific Islander, and Latinx / Hispanic. The percentage of females was 44.8%, males were 45.6% and non-binary was 9.0%. The average age range was between ages 20 to 85.

Materials

The study included two short stories that made up the experimental and control conditions and an image of the ambiguous image that can be seen as either a goose or a hawk (see Figure 1). The experimental story consisted of a scenario describing a series of movements whose direction relative to the participant depends on the participant's height. The story describes the participant as working a busy coat check and hanging coats on a rod. This action requires a downward movement for tall people, but for short people, this action requires an upward movement. The control story consisted of non-directional actions taking place that do not depend on a person's height. The story involves the participant working at a busy coat check and dealing with processing payments while being seated behind a cash register. The full text of the stories is presented in Table 1.

Table 1. Stories participants will read in this experiment.

Experimental Story (Height Dependent)	**Control Story (Height Independent)**
You are busy working at your job hanging coats at a packed theater. The person receiving coats from customers at the counter places a long, furry, black coat on a hanger and shoves it into your arms. You take the coat and gingerly hang it on the rack. Next, you receive a short purple coat, already on a hanger, which you carefully place on the rack. Next, you are given a brown overcoat on a hanger. You take the coat and find a spot for it on the rack. A group of people arrives with three coats: a long trench coat, a pea coat, and a long coat with an itchy fabric. You grab them from your co-worker by the hangers, rush them over to the rack, and place them one by one on the rod. As you scramble to hang four overcoats on the rack, you realize the pace is really picking up!	You are busy working at your job collecting payments at the coat check of a packed theater. You receive a long, furry, black coat from a customer. You gingerly hand the coat to your co-worker and collect five dollars for it. Next, you receive a short purple coat, which you carefully hand to your co-worker, and promptly collect the payment. Next, you are given a brown overcoat. You hand the coat over and place another five dollars in the cash register. A group of people arrives with three coats: a long trench coat, a pea coat, and a long coat with an itchy fabric. You rush them to your co-worker and then collect each payment one by one from the customers. As you scramble to make change for another four people with overcoats, you realize the pace is really picking up!

Participants were also asked to look at an ambiguous image that can be seen as a goose facing one direction or a hawk facing the other (see Figure 1). The image was oriented vertically on the page so that we could measure whether people's attention was guided upward or downward by the story they read. Whether the goose was facing upward or downward was counterbalanced across participants.

Figure 1: Goose/ Hawk Bird Image

The study also included a few demographic questions. The demographic questions asked about participants' age, gender, race/ethnicity, native language, vision, occupation, physical disabilities, height in feet and inches, and how tall they consider themselves to be on a 5-point scale from feeling very short to very tall. Participants also provided an estimate of the height of an average coat rack in feet and inches. They were also asked whether they personally must reach upward or downward to hank a coat on a rack, or whether the rack is at arm's height.

Procedure

In this study, participants were given a consent form at the very beginning before proceeding with the survey. Participants were then directed randomly toward either the experimental or control story. Participants read the story and then saw the goose/ hawk image. They were asked to click on the bird's beak as quickly as possible. They then answered a comprehension question based on the story: “In the story, you read, what was the primary task you were responsible for at your job? (Read all response options carefully before selecting the best answer). 1. Placing coats on a hanger, 2. Hanging coats on a rod, 3. Returning coats to customers, and 4. Collecting payments from customers.” Answer two was correct for experimental participants and answer 4 was correct for control participants. The participants were asked if they noticed anything interesting about the bird image. If they said yes, they were given a text box where they could type in what they noticed. Then they completed the demographic questions described above. The study was pre-registered using AsPredicted.org.

Results

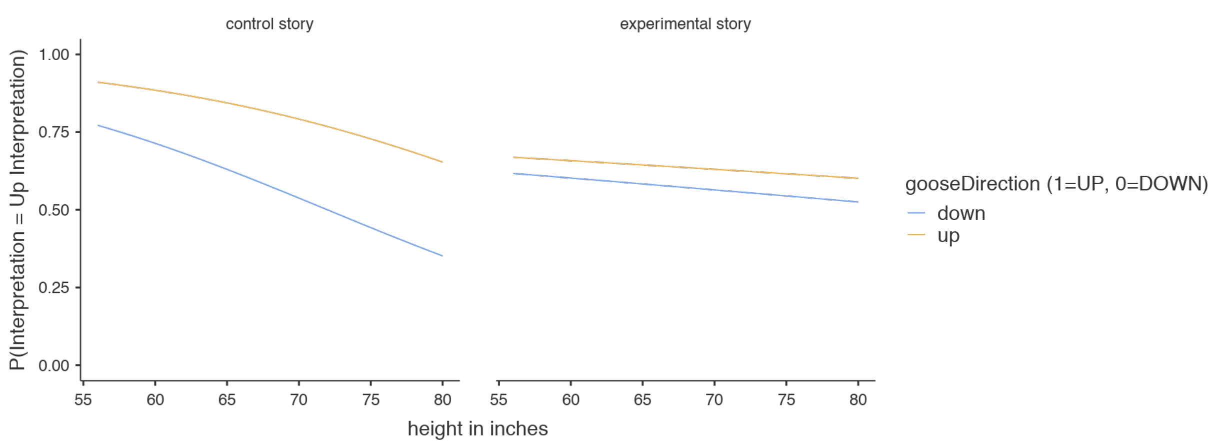
804 participants completed this study. 616 met our inclusion criteria. Participants were excluded if they reported they were not native English speakers (8.3%), did not have normal or corrected-to-normal vision (5%), answered the comprehension question incorrectly (11.4%), did not identify with a binary gender (1.5%), or did not click near either beak within the bird image (5.7%). Participants who clicked on the wings or otherwise far from the beaks were not included in the analyses. Responses were coded as “upward” if the participant clicked within a pre-determined region of interest around the upward facing beak, and responses were coded as “downward” if they clicked on the corresponding region surrounding the downward facing beak.

The data were analyzed using logistic regression with the facing direction of the bird as the outcome variable. Predictors included: the height of the participant in inches, story condition (height dependent vs height independent), facing the direction of the goose (up or down), and gender of the participant (male or female). There was a three-way interaction between the height of the participant, the facing direction of the goose, and the story participants read, $b = -0.38$, *SE*

= 0.18, $\chi^2(1) = 4.21$, $p = .040$ (see Figure 2). To further explore this effect, separate regressions were conducted for the height-dependent and height-independent conditions.

For the height-dependent, experimental condition, there was an effect of the facing direction of the goose, $b = 18.23$, $SE = 8.18$, $\chi^2(1) = 4.99$, $p = .026$. People were biased to see the object as a goose as opposed to a hawk. There was an interaction between the goose direction and height of the participant, $b = -0.27$, $SE = 0.13$, $\chi^2(1) = 4.47$, p = .035. There was an interaction between gender and goose direction, $b = -33.25$, $SE = 11.19$, $\chi^2(1) = 8.84$, $p = .003$. There was a three-way interaction among gender, goose direction, and height, $b = 0.50$, $SE =$ 0.17, $\chi^2(1) = 8.86$, $p = .003$. No other predictors were significant in this model. For the height-independent, control condition, none of the predictors reached significance in the model.

Figure 2: Regression estimates of the effect of height on perceived facing direction of the bird, broken down by story condition (left and right plots) and facing direction of the goose (blue and orange lines).



Discussion

For this research project, the focus was on if language comprehension involves spontaneous, mental imagery and if so, do people with different bodies imagine different things when they understand. The hypotheses were that after reading the height-dependent story, the taller the participant was, the more likely they would be to see a downward-facing bird. After reading the control story, there would be no effect of height on object perception. From the results, the hypotheses were somewhat supported in this experiment. Only in the experimental condition did height significantly affect people's interpretations of the bird image, and, according to the regression estimates, the taller a person was the likelier they were to see a downward-facing bird. These effects were present even when controlling for the gender of the participant. However, there were complicated interactions among all the variables that make this effect difficult to interpret. Numerically, the effects of height on bird interpretation were steeper in the control condition than the experimental condition, but the greater noise in the control condition meant that those patterns were not statistically significant. More work is needed to ensure that the results of the analyses are not statistical flukes.

One limitation of this study was that the experimental story was much more coherent spatially than the control story. Taking a coat and hanging it on a rod specifies a path and a height that is consistent across participants, even if different people must move differently to reach that height. Whereas for the control story, one might imagine being seated on a low chair behind the register and collecting payments from someone who is standing, or one might imagine being seated on a stool or standing, which would change the type of reach that would be necessary to collect the payment. Therefore, there were many directions one could imagine when interpreting the control story. For future versions of this study, the control story should have a coherent horizontal direction instead of a non-directional approach. Another limitation of this study was that participants self-reported their height. In some cases, people provided a height that was impossible (e.g., over 10 feet tall). It would be helpful in future studies to have a way to verify that people were providing an accurate height and reduce unintentional reporting mistakes.

When you read stories or scenarios, does it cause you to imagine what is being described? If so, does that imagery look similar across individuals, or does it depend on a person's physical and perceptual experiences? With this question, we have concluded that the effects of language on perception might depend on height in particular scenarios. In this experiment, we found that an individual's height only affected participants' perception of the ambiguous image if they read a story that required different directions of imagery from short people compared to tall people. However, more work is needed to ensure that this effect was not a statistical artifact.

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