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# See What You Want to See: Motivational Influences on Visual Perception

Emily Balcetis and David Dunning
Cornell University

People's motivational states—their wishes and preferences—influence their processing of visual stimuli. In 5 studies, participants shown an ambiguous figure (e.g., one that could be seen either as the letter *B* or the number *13*) tended to report seeing the interpretation that assigned them to outcomes they favored. This finding was affirmed by unobtrusive and implicit measures of perception (e.g., eye tracking, lexical decision tasks) and by experimental procedures demonstrating that participants were aware only of the single (usually favored) interpretation they saw at the time they viewed the stimulus. These studies suggest that the impact of motivation on information processing extends down into preconscious processing of stimuli in the visual environment and thus guides what the visual system presents to conscious awareness.

*Keywords:* motivation, visual perception, motivated reasoning, New Look, ambiguous figures

The world that people know is the one they take in through their senses. This is the world they react to—the one their conscious thoughts, feelings, and actions are predicated on. People act on the presumption that the world they are consciously aware of is a comprehensive and accurate representation of the environment that exactly copies the outside world as it truly is.

Decades of research in psychology, however, tend to undermine the assumption that what people see or hear is an exact replica of what is out in the world, in two different ways. First, perception is selective. People are not aware of everything that is going on around them. Consider, for example, recent studies of attentional blindness. Of undergraduates asked to monitor how many times people in a videotape pass a basketball among themselves, 40% failed to see the woman in a gorilla suit saunter into the middle of the group, turn to the camera, beat her chest, and then walk out (Simons & Chabris, 1999). Second, perception is often biased. Hills are not as steep as they appear to be (Bhalla & Proffitt, 1999; Creem & Proffitt, 1998; Proffitt, Creem, & Zosh, 2001). Distances are not as short as they look (Baird & Biersdorf, 1967; Durgin, Proffitt, Olson, & Reinke, 1995; Gilinsky, 1951; Tittle, Todd, Perotti, & Norman, 1995; Todd & Bressan, 1990; Todd & Norman, 1991). Large objects are not as tall as they seem (Yang, Dixon, & Proffitt, 1999). Everyone knows that the speck of a pebble at the bottom of one's shoe is never nearly the rock it feels like when one steps on it.

Moreover, perception is malleable. It is responsive to top-down influences that flow from the perceiver's cognitive and psychological states or from environments (Henderson & Hollingworth, 1999). To be sure, much of perception is bottom-up, with sense organs and perceptual systems working inflexibly and automatically to form a representation of a stimulus that the perceiver passively accepts. The perceptual system pieces together the fine-grained bits of information the senses acquire to create a coherent percept, analyzing and synthesizing basic components of objects (Kosslyn & Koenig, 1992; Michelon & Koenig, 2002), including focal areas, critical features (Long & Olszweski, 1999), fixation points (Meng & Tong, 2004; Toppino, 2003), and spatial proximity or *crowding* (Pelli, Palomares, & Majaj, 2004).

But a substantial volume of psychological research reveals that top-down influences also inform perception. For example, context matters. Prior exposure to images of animals or people biases what people see when they view classic ambiguous figures, such as the rat–man and old woman–young woman figures so often featured in introductory psychology textbooks (Bugelski & Alampay, 1961; Leeper, 1935). Estimates of a man's walking speed are biased after thinking about fast animals like cheetahs or slow animals like turtles (Aarts & Dijksterhuis, 2002). Interpretations of an ambiguous figure that can be seen as a woman's face or as a man playing a saxophone depend on whether perceivers have been recently primed with the concepts of "flirtation" or "music" (Balcetis & Dale, 2003). Perceptions of how steep a hill is become more extreme after participants jog vigorously for an hour (Bhalla & Proffitt, 1999). The distance to a goal seems longer if people strap on a heavy backpack (Proffitt, Stefanucci, Banton, & Epstein, 2003).

In the current article, we explore one possible top-down influence on perception that has been shown to have a profound and ubiquitous impact in other arenas of social cognition. That influence is the perceiver's motivational states—more specifically, the motivation to think of one's self and one's prospects in a favorable way, to believe that one will achieve positive outcomes while

Emily Balcetis and David Dunning, Department of Psychology, Cornell University.

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Correspondence concerning this article should be addressed to Emily Balcetis who is now at the Department of Psychology, 200 Porter Hall, Ohio University, Athens, OH 45701 or David Dunning, Department of Psychology, Uris Hall, Cornell University, Ithaca, NY 14853. E-mail: balcetis@ohio.edu or dad6@cornell.edu

being able to avoid aversive ones, and to enhance self-worth and esteem. This motivation in the psychological literature has several names, such as *motivated reasoning*, *self-affirmation, wishful thinking*, and *defensive processing,* and has been shown to have a widespread influence in shaping how people think about their world, that is, how they interpret information of which they are consciously aware. This motive has been shown to influence such higher order tasks as judging other people, evaluating the self, predicting the future, and making sense of the past (for reviews, see Baumeister & Newman, 1994; Dunning, 2001; Kunda, 1990; Pittman, 1998).

In the studies that follow, we examine the scope of motivated reasoning to see if it crosses the boundary between how people think about their outside world and how they perceive it. Certainly, motivated reasoning influences conscious, deliberate, and effortful judgments, but we ask if it can constrain what information reaches consciousness in the first place. Does the impact of motivated reasoning or wishful thinking, more specifically, extend down to preconscious processing of visual information? We test, in essence, whether people literally are prone to see what they want to see.

## The Impact of Motivational States

There exist some indirect hints that the motives underlying wishful thinking have an impact on visual perception. Recent work focusing on more biologically oriented motivational states shows that they influence the perception of visual stimuli. For example, Changizi and Hall (2001) demonstrated that participants who were thirsty perceived more transparency in ambiguous visual stimuli than did those who were not thirsty, presumably because transparency is a characteristic associated with water. Women during periods of high fertility were faster to categorize male photographs than female ones by gender, relative to those not in such a fertile state (Macrae, Alnwick, Milne, & Schloerscheidt, 2002). It is important that the same comparative enhancement was not present for women taking a contraceptive pill or those who were pregnant (Johnston, Arden, Macrae, & Grace, 2003). Both of these examples suggest an enhanced perceptual sensitivity for features in visual stimuli that are relevant to biological drives or desires.

But would a drive toward wishful thinking similarly influence perception? In a sense, this question is a revisiting and a reopening of one of the focal issues of the New Look approach to perception that arose in psychology during the 1940s and 1950s (Bruner & Minturn, 1955). According to New Look theorists, perception was an active and constructive process influenced by many top-down factors. One class of such factors was the needs and values of the perceiver. For example, Bruner and Goodman (1947) asked children in diverse social economic conditions to estimate the size of monetary coins by manipulating the diameter of a beam of light. Poorer children, for whom the value of money was greater, overestimated the size of the coins compared with more affluent children, who were presumed to place less value on the same coins. In studies of perceptual defense, New Look theorists concluded that participants inhibited the recognition of threatening stimuli, such as troubling words (Postman, Bruner, & McGinnies, 1948).

These initial demonstrations of motivational influences on perception were met with much enthusiasm, which was then followed by withering criticism. To be sure, much of what the New Look theorists proposed has lasted through today and informs contemporary cognitive and perceptual psychology in fundamental ways. Psychologists uniformly agree with the New Look tenet that much of cognition happens nonconsciously, that is, outside a person's awareness, monitoring, or control (Greenwald, 1992; Wegner & Bargh, 1998). Many modern textbooks describe the New Look proposal that perception is filtered: that the representation of the environment that people have in consciousness has omitted a good deal of information that is actually in the environment (Allport, 1989; Miller, 1987). Similarly, perception of an object is importantly influenced by the perceiver's expectations as well as the context surrounding that object (Biederman, Mezzanotte, & Rabinowitz, 1982; Boyce & Pollatsek, 1992; Li & Warren, 2004; Long & Toppino, 2004).

However, the specific New Look assertion that motivational states influence perception did not achieve the same stature and longevity as these other insights. It, instead, ran aground in the 1950s on the rocky shoals of methodological difficulties and theoretical controversies (Eriksen, 1958, 1962; Eriksen & Browne, 1956; Goldiamond, 1958; Prentice, 1958; Wohlwill, 1966). Critics pointed out that poorer children might misjudge the size of coins because they were not as familiar with them, or that their misjudgments might involve problems of memory rather than perception (McCurdy, 1956). Critics also noted in studies of perceptual defense that participants might have taken longer to report troubling words not because it took them longer to perceive them but rather because it took longer to get over the surprise of seeing them or the embarrassment of saying them (Erdelyi, 1974, 1985). Others lamented that the relative unfamiliarity of threatening words, and not their motivational punch, was the key ingredient that slowed participants' recognition responses (Adkins, 1956; Howes & Solomon, 1950).

As such, the influence of motivational states on perception was never firmly established. And as the 1950s closed the study of the relation between motivational states and perception, this pursuit fell by the wayside and ceased to have the major impact—if any at all—enjoyed by other insights from the New Look tradition (Dunning, 2001; Erdelyi, 1974; Gilbert, 1998; Jones, 1985; Nisbett & Ross, 1980).

## Perception of Ambiguous Figures

In the present research, we examined the impact of motivational states on perception by focusing on interpretations of ambiguous or reversible figures—visual stimuli, like the famous Necker cube, that people can interpret in two different ways but for which they tend to see only one interpretation at any given time (Long & Toppino, 2004; Rock & Mitchener, 1992).

In each of five studies, we told participants that they were about to be assigned to one of two experimental tasks, one being much more desirable than the other. We also told participants that a computer sitting in front of them was about to present them a stimulus that would indicate which task they were assigned to. In fact, in each study, the computer presented a figure that could be interpreted in two different ways: one way that would assign participants to their favored task and one that would assign them to the opposite. We expected that participants would tend to see the interpretation that assigned them to the outcome they favored.

Because our experimental stimuli, like much of the contents of our surroundings, lack clarity and contain multiple interpretations, potential interpretations of a visual stimulus can be likened to a hypothesis (Gregory, 1974). Given a constrained set of bottom-up features and top-down influences, the perceptual system considers certain ideas of what an ambiguous stimulus might be and ultimately selects one interpretation. For example, given the distinct features of a four-legged shape in a distant field, one can entertain different hypotheses about the identity of the shape. For example, to test whether the shape is a cow, the perceiver might examine whether the shape has a stocky snout and black spots.

Just as expectancies and contexts can suggest a testable perceptual hypothesis, a preference or desire might privilege a favored interpretation or hypothesis over a disfavored one. Wishful thinking might shape the specific hypothesis that individuals test when given such ambiguous information. In particular, the perceiver might scan the visual stimulus in a biased manner, searching for features that match those of the desired animal rather than those that match an undesired one. The net effect of focusing on a hypothesis is that the perceiver tends to seek out information that would confirm it rather than disconfirm it (Pyszczynski & Greenberg, 1987; Sanitioso, Kunda, & Fong, 1990).

Alternatively, a motivated preference might lower the threshold required for the visual system to decide it matches the favored interpretation. Other work in motivated reasoning has shown that information consistent with a favored conclusion is held to a lower standard of scrutiny than information consistent with an unwanted one (Dawson, Gilovich, & Regan, 2002; Ditto & Lopez, 1992; Trope & Ferguson, 2001). It could be then that those features most representative of the desired animal category are recognized faster or more easily because the perceiver requires less of a match between what he or she hopes to see and what is offered by the stimulus.

The key to whatever process is at play is that it takes place preconsciously. People are not aware that they have selected one interpretation over another. Indeed, they are not even aware of the alternative interpretation. Whatever work the visual system has done to bias the interpretation that people see involves processes below the level of awareness.

## Overview of Studies

Studies 1 and 2 demonstrated that participants tended to report seeing the interpretation of an ambiguous figure that fit with their wishes and preferences over one that did not. Studies 3 and 4 added implicit measures to ensure that participants truly saw the interpretation they reported rather than simply reporting the preferred interpretation. Study 5 added a procedural twist to affirm that participants saw only the interpretation they usually wanted to see as they viewed the stimulus and that it was not the case that they saw both interpretations and then only reported the favored one. In short, people tended to honestly see only that interpretation that was suggested, in part, by their motivational state.

## Study 1: Disambiguating an Ambiguous Figure

Study 1 was designed to provide an initial demonstration that wishful thinking could influence the interpretation of an ambiguous stimulus. Participants were brought into the laboratory and told that they would be assigned to one of two tasks. One was favored (i.e., drinking freshly squeezed orange juice); the other was not (i.e., drinking a noxious-smelling and vile-looking health food drink). They were told that the computer would assign their beverage by presenting either a number or a letter. For roughly half of participants, a letter would indicate that they were assigned to the desirable beverage. For the other half, the reverse was true. However, what the computer flashed very briefly was an ambiguous figure that could be interpreted either as a number or letter. Our prediction was that participants would tend to report seeing the interpretation that offered them the coveted beverage.

### Method

*Participants.* Participants were 88 undergraduates at Cornell University who earned extra credit in their psychology or human development courses for taking part in the study.

*Procedure.* In what was advertised as a taste-testing experiment, an experimenter explained that participants would predict taste sensations for two beverages, consume only one beverage, and describe their actual taste sensation of that one beverage. On the table in front of participants sat the two beverages. The first was the desirable one: freshly squeezed orange juice. The second was the less desirable alternative: a gelatinous, chunky, green, foul-smelling, somewhat viscous concoction labeled as an "organic veggie smoothie."[1] The experimenter invited participants first to smell each beverage. Then, participants spent 3 min predicting what they might experience if asked to drink 8 ounces (about 240 ml) of each beverage to heighten the appeal of the orange juice and strengthen their disgust with the veggie smoothie.

Participants were seated in front of a 15-in. G3 iBook. The experimenter then explained that a computer program would randomly select a beverage for the participant to consume. Specifically, the computer would select either a single letter or a single number from a set of 26 letters and 26 numbers. Roughly half of the participants, those in the number-desirable condition, were told that if the computer selected a number from the set, they would drink 8 ounces (about 240 ml) of orange juice, and if a letter was selected, they would drink 8 ounces (about 240 ml) of veggie smoothie. The remaining participants in the letter-desirable condition learned that a letter would result in their assignment to the orange juice and a number to the veggie smoothie.

After inviting the participant to review these directions on a computer screen, the experimenter stepped away to ostensibly complete some paperwork. Participants focused on the center of the monitor on which was displayed a static fixation point. After 3 s, this fixation point was replaced with an ambiguous figure (1 in. in height, 1 in. in width) that could be interpreted as either the capital letter *B* or the number *13* (see Figure 1) for 400 ms. The presentation of this figure was followed by a 200-ms mask and then finally by an image that was meant to look as though the computer program had crashed. The experimenter continued to focus on the paperwork until the participant called her attention to the computer crash. The experimenter feigned surprise, exclaimed that "this always happens to old Macs," and stated that she would have to ask the graduate student she worked for what she should do. As the experimenter approached the door to leave the lab, she asked if the program displayed anything before crashing. At this point, most participants reported whether they saw a *B* or a *13*. If participants did not offer a response, the experimenter asked again if anything was shown or if it immediately crashed. If at this point participants still refused an answer, the experimenter left the room and returned a few minutes later to ask a final time if anything was shown.

After receiving an answer, the experimenter handed the participant a questionnaire to complete while she supposedly left to prepare the bever-

[1] Recipe available on request.

*Figure 1.* Ambiguous B–13 figure used in Study 1.

age. This questionnaire probed for suspicion of the purpose of the study, suspicion of the computer crash, and in a funneled manner queried participants to see if they realized the ambiguity in the figure shown before the computer crash.

### *Results*

A priori, we established conditions for the inclusion of participants' data. Participants were excluded if they recognized the figure was ambiguous, were able to explain the purpose of the study in debriefing, or mentioned they wished to be assigned to what was considered by most participants to be the less desired task (i.e., consumption of veggie smoothie). Given these criteria, 15 people were excluded for recognizing the ambiguity in the figure when viewing the figure, 4 for explaining that we were interested in how their desires could influence the way they saw the figure, 3 for stating they hoped to consume the smoothie, and 3 simply refused to participate when they heard that they might be asked to consume the smoothie. This left data from 63 participants for analysis. Although a few participants indicated the computer crash was suspicious, none of these participants were able to describe the purpose of the study or the reason for the crash.

Responses from those 63 participants were coded by means of the following method. Reports of the letter *B* were given a score of +1, and reports of the number *13* a score of −1. Those who did not offer a response or indicated that nothing was shown before the crash received a score of 0. We then subjected these scores to an ordinal logistical regression analysis (the constrained range of the coding system made more usual statistical procedures less appropriate) to see if participants tended to see different interpretations of the ambiguous figure depending on which interpretation was more desirable. As expected, participants' desire to see either letters or numbers influenced their interpretation of the B–13 ambiguous figure, $\chi^2(1, N = 63) = 23.92$, $p < .001$. In particular, when hoping to see a letter, 72% ($n = 18$) of participants reported seeing the capital letter *B*, whereas 0% reported seeing a *13*. When hoping to see a number, 60.5% ($n = 23$) reported seeing a *13* and 23.7% ($n = 9$) reported seeing the *B*. Some people in each condition reported that in fact nothing was shown before the crash (28%, $n = 7$, in the letter-favorable condition; 15.8%, $n = 6$, in the number-favorable condition).

Our specific prediction focuses on the responses of those who offered an interpretation of the figure. When excluding those responses from participants who reported that nothing was shown before the crash, participants' desire to see either letters or numbers influenced their interpretation of the B–13 ambiguous figure, $\chi^2(1, N = 50) = 23.96$, $p < .001$. Additionally, we can collapse across the specific character participants were motivated to see and look at just the reported interpretation for those participants who offered one. In fact, 82% ($n = 41$) of participants reported the desired interpretation, $\chi^2(1, N = 50) = 20.48$, $p < .001$.

In addition, including those people in the analyses who indicated that the figure was ambiguous does not change this pattern, as similar numbers of participants across both motivational conditions reported the ambiguity of the figure ($n = 8$, when hoping to see letters; $n = 7$, when hoping to see numbers). That is, we gave a score of 0 to those people who indicated the figure was ambiguous and again conducted an ordinal logistic regression. Still, participants' desire to see either a letter or a number influenced their interpretation of the ambiguous figure, $\chi^2(1, N = 78) = 22.95$, $p < .001$.

### *Discussion*

In sum, Study 1 provided evidence that people's motivational states can influence their interpretation of ambiguous objects in their environment. When faced with an ambiguous figure that could be interpreted as either a number or letter, the interpretation that reached consciousness and was reported tended to be the one that placed participants in a desirable circumstance rather than in an unwanted one.

However, it is possible that the participants' responses did not reflect their true percept. Instead of reporting what they saw, they instead just offered a report that assigned them to the orange juice. Put simply, participants may have lied about what they saw. Although we suspect this is not the case, we conducted a follow-up to assess this counterexplanation. In a design similar to Study 1, 28 participants were either motivated to see letters or numbers to avoid the veggie smoothie but were then shown unambiguous figures of *B* or *13*, rather than an ambiguous figure, during the computer assignment process. For half of the participants, a letter assigned them to the orange juice, whereas for the other half a number assigned them to the veggie smoothie. Crossed with this, half of the participants were shown a *B* and the other half were shown a *13*, resulting in a 2 (desired character: letter or number) × 2 (character shown: *B* or *13*) factorial.

The alternative account predicts that participants' reports of the figure shown to them would be influenced by which character was desired as well as what character was shown to them. However, inconsistent with that account, we found that what participants reported depended only on the character shown to them. In all conditions, 100% of participants ($n = 7$ in every cell) reported the actual figure shown, regardless of what figure was shown to them and what participants were motivated to see.

## Study 2: Replication

Study 2 was designed as a conceptual replication involving a different ambiguous figure and a different procedure. In addition, in Study 1, we noted that a small but notable minority of participants was able to spot the ambiguity of the figure we showed them. In Study 2, we used a figure whose ambiguity was more opaque and thus not as likely to be noticed by participants.

## Method

*Participants.* Participants were 52 undergraduates at Cornell University who received extra credit in their psychology course for taking part.

*Procedure.* Participants completed a task ostensibly about differences in predictions of and actual taste experiences. The experimenter explained that participants would be experiencing and describing different taste sensations. Participants would predict taste sensations for three food items but actually consume only one of them. First, participants predicted what each of the following items would taste like: a bottle of Aquafina water, a bag of Jelly Belly candies, and a bag of gelatinous and partially liquified canned beans.

After participants predicted taste sensations of each item, participants were seated in front of a 17-in. iMac 64 desktop computer. Again, supposedly to eliminate bias from the selection process, a computer program would randomly assign the item participants would consume. The experimenter explained that participants would play a game, and their final score would determine what item was consumed. In this game, the computer displayed pictures of animals worth positive and negative points. On the top of their response sheet was a table listing every animal that could be selected and the specific number of points each animal was worth. For half of the participants, farm animals were worth positive points, whereas sea creatures were worth negative points. For the other half of participants, this was reversed. Black and white drawings of the full bodies, heads, and artistic renditions of animals were displayed in the rounds that preceded the final round.

Although the computer would be keeping an ongoing tally of the points accumulated, participants recorded the animal shown to them, the points that animal was worth, and their ongoing score ostensibly to corroborate the computer program. If their score at the end of 15 cards was zero, participants would consume the water. If their score was positive, they would consume the candies, but if their score at the end was negative, participants would consume the canned beans. Although participants were told that the program randomly selected animals from a set of four farm animals and four sea animals, the program was actually rigged such that every participant experienced one of two sequences of animals and point tallies, depending on what category of animal was worth positive point values.

As the game progressed, ongoing scores, predetermined and consistent across participants, fluctuated between positive and negative. However, the last three rounds brought increasingly negative point totals. That is, ongoing scores became ever more suggestive that participants would consume the canned beans. Ongoing scores at the end of the penultimate round were such that only one animal was worth enough positive points to be able to pull participants from the negative and bring a positive final score, thus avoiding the canned beans. For half of the participants, this animal was a horse; for the other half, it was a seal. The animal displayed during the final trial was in fact an ambiguous figure (2.75 in. wide, 3.75 in. tall) that could be interpreted as either the head of a horse or the full body of a seal (see Figure 2; from Fisher, 1968). All animals, including the last figure, remained on the screen for 1,000 ms.

After the game, participants completed a funneled debriefing that probed for suspicion of the purpose of the study, possible alternate interpretations of the figure, and asked if they had seen the figure before.

## Results

Given the criteria we established a priori, 5 participants were excluded for articulating the purpose of the study and 4 for mathematical errors that precluded them from desiring the target animal. No one reported seeing both interpretations of the ambiguous figure. These omissions left data from 43 participants for analysis.

*Figure 2.* Ambiguous horse–seal figure used in Studies 2–4. From "Ambiguity of Form: Old and New," by G. H. Fisher, 1968, *Perception & Psychophysics, 4,* p. 191. Copyright 1968 by the Psychonomics Society. Reprinted with permission.

We used the same type of coding scheme for interpretations as in the previous studies. Given the natural bias of this ambiguous figure was to see a horse, those who reported a horse received a score of +1. Because the less common interpretation of the figure was as a seal, those who reported a seal received a score of −1. Using an ordinal logistic regression, we found that participants' interpretations depended on what category of animal was worth positive points, $\chi^2(1, N = 43) = 6.89$, $p = .009$. When hoping to see a horse, 66.7% ($n = 14$) of participants saw the figure as a horse, and 33.3% ($n = 7$) saw a seal. However, this bias reversed when hoping to see a seal. Only 27.3% ($n = 6$) of this group saw a horse, but 72.7% ($n = 16$) reported a seal, $\chi^2(1, N = 23) = 6.70$, $p = .01$.

## Discussion

In sum, Study 2 replicated the findings of the first study with a different figure and experimental procedure. Participants tended to see the interpretation of the figure that they desired to see, rather than one they wished to avoid. In addition, no participant, either spontaneously or in debriefing, noted the ambiguous nature of the figure they saw.

However, a reader can propose one counterexplanation for these findings, one that we decided to test in a control study. Given that the three rounds preceding the ambiguous figure included animals that brought participants' scores down, it is possible that participants' expectations about the next type of animal and not their desire predisposed them to see an animal worth positive points. That is, participants fell prey to a gambler's fallacy, assuming that a run of negative scores made positive-scoring animals more likely to appear next.

To test this alternative explanation, we reran a version of Study 2, asking participants to follow along with the computer game and to record their points on a response sheet. However, we made clear to them that they would not be consuming any products after the game and that there would be no consequence for the final score they earned. Instead, they were to act as proofreaders, reading the directions thoroughly and evaluating the clarity of them. As was the case in Study 2, half of the participants encountered a game that made the horse the most valuable animal, whereas the other half were led to believe the seal was the most valuable animal. Thus, this group of participants, aware of the point structure and the progression of animals, would also be susceptible to the gambler's fallacy but would have little reason to be motivated to see the most valuable animal in the final round.

In this control study, interpretations of the figure were not biased by what animals were most valuable. Those for whom farm animals would have been the most valuable were not more likely to see a horse than were those for whom sea animals would have been the most valuable, $\chi^2(1, N = 40) = 0.11$, $p = .74$. When farm animals were the most valuable, 65% ($n = 13$) of participants saw the figure as a horse, and 35% ($n = 7$) saw it as a seal. When sea creatures were the most valuable, 70% ($n = 14$) saw the figure as a horse, and 30% ($n = 6$) saw it as a seal.

The results of this study can be compared with those of Study 2 to suggest that reducing desire to see a particular animal can reduce the bias in interpretations. Because we are making comparisons across studies, it is necessary to use a Stouffer's $Z$ test (see Darlington & Hayes, 2000, for a review) to test if the effect of desire in Study 2 is sufficiently different from the effect of desire in this control study. That turns out to be the case ($Z = 2.58$, $p < .005$).

## Study 3: Adding an Unobtrusive Measure

Study 3 was designed to provide convergent evidence that the interpretations participants reported were, indeed, the sole interpretations that came to consciousness as they viewed the ambiguous stimulus. One can propose, instead, that participants saw both interpretations and then simply chose the one to tell the experimenter that placed them in a happier circumstance.

One way to test whether participants saw only one versus both interpretations is to collect more unobtrusive measures that participants would not suspect were designed to test which interpretation they had seen—if they knew the measure was being taken at all. As was the case in the previous studies, we asked participants to provide a verbal or written report of whether they had seen a horse or a seal after being shown a figure that could be interpreted as either. However, in addition, we also measured participants' eye movements to see if they would give clues as to how participants had interpreted the figure. Recent evidence suggests that initial eye movements on presentation of a stimulus are not influenced by conscious processing (Allopenna, Magnuson, & Tanenhaus, 1998; Richardson & Spivey, 2000; Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995). Thus, we examined whether the first saccade (eye movement) after presentation of the ambiguous figure would be to a label on the computer screen marked "farm animal" or one marked "sea creature." We expected that such saccades would indicate that participants had interpreted the figure in a way that placed them in a favorable circumstance.

### Method

*Participants.* Participants were 79 undergraduates at Cornell University completing the study in exchange for extra credit.

*Procedure.* Participants came into the lab alone and were seated approximately 20 in. from a 21-in. Apple cinema-display monitor (17 in. viewable). As was the case in previous studies, participants completed a task ostensibly about differences in predictions of and actual taste experiences of Aquafina, orange juice, and veggie smoothie. After participants predicted taste sensations of each item, the experimenter explained that to eliminate bias from the selection process, a computer program would randomly assign the item they would consume on the basis of their score at the end of a game similar to the one used in Study 2. As described in the previous study, the computer displayed pictures of farm and sea animals counterbalanced between participants to be worth either positive or negative points. Participants kept a record of the animal shown to them, the points that the animal was worth, and their ongoing score, ostensibly to corroborate with the computer program.

Participants were told that although the computer would be keeping an ongoing tally of the points accumulated, they would still categorize the animal as either a farm animal or sea creature by clicking on a box on the computer screen to advance the computer to the next animal. The program displayed each animal for 1,000 ms, followed by a 500-ms blank screen, and finally a request to categorize the figure, which remained on the screen until participants responded. On the extreme left side of the categorization screen was a box labeled "farm animal," and on the extreme right was a box labeled "sea creature." Participants were instructed to categorize the animals on the computer correctly to avoid point penalties. In addition to losing points for incorrect categorization, participants learned that a portion of their final score would be determined by the speed of their categorization; thus, they were advised to categorize animals as quickly as possible.

Unbeknownst to the participants, a video camera was hidden approximately 15 in. behind the monitor and trained on participants' eyes. Thus, every time the categorization task appeared on the cinema-display monitor, we were able to capture participants' initial eye movements. As practice to familiarize them with the task of viewing and categorizing animals, participants categorized filler animals eight times. After this practice session, participants completed 15 trials, the last of which displayed the ambiguous figure. Thus, participants were well-acquainted with the three-step process to complete a single trial: (a) view the animal, (b) categorize the animal on the computer screen, and (c) record the animal and points on the written response sheet.

We were interested in the way in which participants interpreted the ambiguous figure. Their interpretation was measured in two ways: the written self-report and participants' eye movements immediately on perceiving the categorization screen. Given that initial eye movements are not influenced by conscious processing (Richardson & Spivey, 2000), we can suppose that immediate looks at either the farm animal or sea creature box are representative of participants' interpretations of the figure without concern for conscious, calculated response selection.

We expected then that desire to see a particular animal would influence the way that the ambiguous figure was reported on the response sheet. Specifically, we expected that participants, hoping to drink orange juice, would see the most valuable animal. In addition, we expected that participants' eye movements would corroborate their self-reports such that initial saccades would be toward the box labeled as the most desired animal.

*Coder reliability.* A coder, blind to condition, hypotheses, and purpose of the study watched the videotaped eye movements and noted the initial direction of movement for half of the data set. For the other half of the data set, a second coder, blind to condition, coded the videotaped eye movements. A third coder, blind to condition, randomly selected 18 participants from the complete data set and noted the initial direction of eye movement. Eye movements recorded by this third coder then served as a measure of interrater reliability. Across 213 individual trials from the 18 randomly selected participants, the third coder and the original coder agreed in 92% of the cases. If there was disagreement, the direction of eye movement as indicated from the original coder was used in analyses.

In addition, to assess the validity of our nonconscious measure of initial eye movement and to see whether eye movements corresponded to what participants later reported, we randomly selected 48 participants and coded their eye movements in response to the 10 unambiguous animals that preceded the ambiguous figure. Across 480 trials, initial eye movements went to the correct categorization box 86% of the time.

### Results

*Explicit reports.* Using the same coding scheme as in the previous studies that used the horse–seal ambiguous figure, we again ran an ordinal logistic regression. As expected, desire facilitated the disambiguation of the figure, $\chi^2(1, N = 79) = 5.62, p < .02$. When hoping to see farm animals, 83.7% ($n$ = 36) of participants saw the figure as a horse, and 16.3% ($n$ = 7) saw a seal. However, the pattern changed when participants hoped to see sea creatures. That is, 58.3% ($n$ = 21) of this group saw a horse, 33.3% ($n$ = 12) reported a seal, and 8.3% ($n$ = 3) of participants did not indicate their interpretation. When looking only at the interpretations of those who offered one, it appears that desire influenced the disambiguation of the figure. Those who were motivated to see farm animals were more likely to report seeing a horse than were those who were motivated to see sea animals, $\chi^2(1, N = 76) = 4.02, p < .05$.

*Eye movements.* We used the same coding scheme in analyzing the interpretations gathered from participants' eye movements. Again, those whose initial look was to the farm animal box received a score of 1, those who initially looked to the sea creature box received a score of −1, and those who looked down to their response sheet and not to either the farm animal or sea creature box received a score of 0.

We conducted an ordinal logistic regression and found that desire facilitated the disambiguation of the figure, $\chi^2(1, N = 79) = 10.24, p < .001$. When hoping to see farm animals, 62.8% ($n$ = 27) of participants looked to the farm animal box, 14.0% ($n$ = 6) looked to the sea creature box, and 23.3% ($n$ = 10) looked down to their score sheet. However, the pattern changed when participants hoped to see sea animals. That is, 30.6% ($n$ = 11) looked to the farm animal box, 41.7% ($n$ = 15) looked to the sea creature box, and 27.8% ($n$ = 10) looked down to their score sheet. When looking only at the interpretations of those who looked to either box, it appears that desire influenced the disambiguation of the figure. Those who were motivated to see farm animals were more likely to look to the farm animal box than were those who were motivated to see sea animals, $\chi^2(1, N = 59) = 9.90, p = .002$. We should note that scores on our eye-tracking measure significantly correlated with the score participants received from their explicit reports (Spearman's $\rho = .42, p < .001$).

## Study 4: Converging Evidence from Lexical Decision Data

Study 4 served as a conceptual replication of Study 3 but used a different type of indirect measure of perception. A good deal of research (e.g., Neely, 1991) suggests that a picture of an object serves as a prime for concepts associated with that object, even if people are not aware that they have seen the object (e.g., Loach & Mari-Beffa, 2003; Raymond, Shapiro, & Arnell, 1992). Thus, in Study 3, we motivated participants to interpret an ambiguous figure as either a horse or a seal. Participants again provided an explicit report of the interpretation they saw.

However, we also collected reaction time data to gain an additional measure of whether participants had specifically seen the interpretation they had reported—and only that interpretation. Just after viewing the figure, participants completed a lexical decision task (LDT) in which they were presented with letter strings and had to decide whether those letter strings formed English words. Each participant saw a word related to the concept of "horse" (e.g., *cowboy*) or "seal" (e.g., *blubber*). We predicted that participants would respond more quickly to a word in the LDT exercise when that word was related to the interpretation they preferred to see rather than to the opposite interpretation. If participants actually saw both interpretations, no such difference should be seen in participants' decision speed to words related to desired versus undesired interpretations.

We also wanted to make sure that participants' interpretations of the ambiguous figure were indeed responsible for priming their reactions in the LDT, rather than an overall desire to see a farm animal or sea creature. Thus, as a control condition, roughly half of the participants responded to the LDT just before they saw the ambiguous figure rather than just afterward. If participants responded more quickly to desired-concept words to a greater degree after they viewed the ambiguous figure, that fact would suggest that the interpretation participants saw was the one influencing the speed of their lexical decisions. However, if just a desire to see one type of animal over the other is enough to prime performance in the LDT, then desired-concept words should be facilitated in both before and after conditions to an equal degree.

This design also allowed us to investigate one mechanism by which participants' perceptions were influenced. Collecting LDT reaction times just before participants viewed the ambiguous figure allowed us to gauge whether people's preferences suggested a *perceptual set* (Bruner & Minturn, 1955), that is, a preparedness to see the ambiguous figure as the desired object rather than the alternative. If participants provided quicker reaction times to words associated with the desired object than they did to words associated with the undesirable object, that pattern would be suggestive of a perceptual set.

### Method

*Participants.* Participants were 166 undergraduates at Cornell University who received extra credit in their psychology courses for taking part.

*Procedure.* Participants came into the lab in groups of 2 to 4 to complete a task ostensibly about differences in internal and external evaluations of vocal abilities. The experimenter explained that approximately 75% of participants would evaluate various aspects of a person's vocal performance, whereas the remaining 25% would be asked to perform a tune as if in a karaoke bar. The experimenter clarified that these percentages meant that approximately 1 person in each session would be the singer and subject of evaluation, whereas the remaining people would be observers. After performing a tune, singers would evaluate their own vocal abilities on rhythmic ability, skill, and general appeal. The experimenter explained that these scores would be corroborated against those provided by the observers on the same dimensions. At this point, participants were shown a 60-s video clip ostensibly of past participants and observers completing the performance evaluation portion of the experiment to heighten anxiety about the potential assignment to the singer role. In this video, a stocky Italian man in his early 20s held a microphone while singing and dancing along to Gloria Gaynor's 1979 rendition of "I Will Survive."

Participants were seated approximately 24–26 in. from a 17-in. iMac G4 or a 17-in. eMac desktop computer. As was the case in previous experiments, the experimenter explained that to eliminate bias from the selection process, a computer program would randomly assign participants to either the role of singer or observer. Participants played the same animal game as described in Study 3, ostensibly to determine whether they danced or observed. Again, participants kept a record of the animal shown to them, the points that the animal was worth, and their ongoing score, ostensibly to corroborate with the computer program. Additionally, participants categorized the animal as either a farm animal or sea creature on the computer.

Finally, participants completed a number of LDTs during the animal categorization task, supposedly meant to impair their ability to categorize the animals. That is, participants categorized strings of letters as words or nonwords. In a go/no-go paradigm, participants hit the space bar if the string of letters was a word and did nothing if the string of letters was not a word. All strings of letters disappeared from the screen if no key was hit within 2,000 ms.

Participants randomly assigned to the control condition completed the LDT at the beginning of each trial, that is, before seeing each animal. Participants randomly assigned to the experimental condition completed the LDT at the end of each trial, after seeing each animal but before categorizing it on the computer or recording it on their response sheet. Participants completed between one and three lexical decisions during each trial for the first 12 trials. In the last round, participants responded to three strings of letters. In this last trial, all participants responded to one word related to farm animals, one related to sea animals, and one nonword, the order of which were counterbalanced between subjects. Although for each participant only a single farm- and sea-relevant word was included in the last trial, the particular word selected was counterbalanced between subjects. Specifically, there were four words related to farm animals (*cowboy, saddle, stallion, pasture*), four words related to sea animals (*blubber, flipper, ocean, whale*), and four nonwords (*blevre, yaver, dreas, puli*) that were varied between subjects. That is, a participant would react to a single word from each of these sets.

Again, the ongoing score at the end of the penultimate round were such that only one animal was worth enough positive points to produce an assignment to the observer role. For roughly half of the participants, the only animal capable of this was a horse, whereas for the other half, it was a seal. The last animal displayed was again the horse–seal ambiguous figure.

We presumed that participants, going into the final trial with a negative score, would be hoping to see the animal worth the greatest number of positive points. We expected then that desire to see a particular animal would influence the way that the ambiguous figure was interpreted. Additionally, we expected that the desire to see a particular set of animals would influence the speed at which the target words was categorized, but only after participants had viewed the ambiguous figure. In particular, we expected that the control group that completed the LDTs before seeing the ambiguous figure would be equally likely to categorize the horse-relevant fragments and seal-relevant fragments as words. However, we expected that the experimental condition that completed the LDTs after having seen the ambiguous figure and interpreted it as the desired animal would be faster to categorize words related to the desired animal type. Specifically, those participants in the experimental condition for whom farm animals were worth positive points were expected to categorize the farm-relevant words faster than sea-relevant words.

## *Results*

Although a small number of participants questioned why they had to play a computer game to determine their role, no participant was able to explain the purpose of the study. Additionally, in debriefing, some indicated disbelief that the performance evaluation component of the experiment would take place. Again, these people were unable to explain the purpose of the study. Thus, no participant was excluded for either of these reasons.

*Explicit reports.* Omitting the one participant who did not offer an interpretation, we calculated the proportion of participants who had reported seeing a horse in each cell in a 2 (desired animal type: farm or sea) × 2 (task order: LDT before or after figure) design. Performing arcsin transforms on these proportions by means of the procedure outlined by Langer and Abelson (1972), allowed us to assess all main effects and interactions inherent in the design. This analysis indicated that desire facilitated the disambiguation of the figure. Whether or not participants saw a horse or a seal depended on whether participants were motivated to see farm animals or sea animals ($z = 4.15$, $p < .001$). No other effects were significant. When hoping to see farm animals, 97.2% ($n = 69$) of participants saw the figure as a horse, and 2.8% ($n = 2$) saw a seal. However, the pattern changed when participants hoped to see sea creatures. That is, 76.0% ($n = 73$) of this group saw a horse, 22.9% ($n = 22$) reported a seal, and 1.0% ($n = 1$) of participants did not indicate their interpretation.

*LDT.* However, we were most interested in the speed with which strings of letters were categorized as words. The complete design was a 2 (word type: related to farm or sea animals) × 2 (desired animal: farm or sea) × 2 (task order: LDT before or after the ambiguous figure) with the first variable being within-subjects.

Two participants (1 in the farm animal control condition, 1 in the sea animal experimental condition) made errors in categorizing during the LDT; their data are omitted. Given the skewed nature of the reaction time data, we conducted all analyses on natural log transformations. However, note all means reported in the text and tables are the original reaction times. In general, participants were no faster at responding to farm or sea words, $F(1, 159) = 2.14$, $p = .15$. Likewise, participants were no faster at responding to words when motivated to see either farm or sea animals, $F(1, 159) < 1$, $p = .54$. However, unexpectedly, it appears that those who completed the LDT before seeing the figure were generally faster ($M = 778$ ms, $SE = 15$) to respond than those completing the LDT after seeing the figure ($M = 890$ ms, $SE = 27$), $F(1, 159) = 13.97$, $p < .001$. Presumably, after viewing the ambiguous figure, participants were slowed somewhat, knowing that they would soon have to report the category of the creature they had seen.

More interesting, the 2-way interaction between word type and desired animal was significant, $F(1, 161) = 4.00$, $p = .05$; but this interaction was qualified by the predicted 3-way interaction between word type, desired animal, and LDT time, $F(1, 159) = 5.99$, $p = .02$. As seen in Table 1, when completing the LDT before seeing the figure, the motivation to see a particular type of animal influenced the speed at which participants reacted to the words, as

Table 1
*Reaction Times (ms) to Identify Word as a Function of Timing of Lexical Decision Task (LDT) and Desired Interpretation of the Ambiguous Figure*

| Timing of LDT task and desired interpretation | Target word: Farm related *M* | Farm related *SE* | Sea related *M* | Sea related *SE* | Difference |
|---|---|---|---|---|---|
| Before | | | | | |
| Horse | 746 | 43 | 819 | 53 | −73 |
| Seal | 815 | 29 | 730 | 36 | 85 |
| After | | | | | |
| Horse | 716 | 37 | 1034 | 42 | −318 |
| Seal | 958 | 46 | 853 | 52 | 105 |

confirmed by a significant Desired Animal × Word Type interaction that focused only on participants in the before condition, $F(1, 91) = 5.49$, $p = .02$. Participants responded to words associated with the desired category more quickly than they did to words associated with the undesired category. However, this advantage for words associated with desired categories was significantly stronger for participants completing the LDT after viewing the ambiguous figure, as evidenced by a significant Desired Animal × Word Type interaction, $F(1, 68) = 25.05$, $p < .001$. That is, those motivated to see farm animals responded faster to farm-related words than sea-related words by some 318 ms. Those motivated to see sea animals were faster to respond to sea-related words than farm-related words by some 105 ms.[2] Unlike Study 3, for participants in the group who viewed the ambiguous figure before completing the LDT, scores on this implicit measure (reaction time to farm words minus reaction time to sea words) did not correlate with their explicit reports (point-biserial $r = .05$).

*Summary.* In sum, Study 4 provided more convergent evidence that participants were more likely to interpret an ambiguous figure in line with their preferences. Participants again were more likely to explicitly report seeing a horse or a seal when they preferred to see that animal relative to when they did not. Their performance on an LDT also indicated that they had interpreted the ambiguous figure in a manner consistent with their desires. After seeing the ambiguous figure, participants recognized those words associated with the desired animal more quickly than they did words associated with an undesired animal, indicating that they had seen only the interpretation consistent with their desires. This performance advantage for words associated with desired animals was not as evident when participants completed an LDT before they viewed the ambiguous figure.

However, participants who completed the LDT before they viewed the ambiguous figure still classified words associated with the desired interpretation more quickly than they did words associated with the opposite, although this tendency was much more muted relative to participants completing the lexical task after viewing the figure. This last result suggests a hint of a perceptual set: Participants showed some preparation or bias to see the desired interpretation over the undesired one before viewing the stimulus. However, this result is preliminary and tentative, and there is much more to explore regarding the processes that lead people to see what they want to see.

## Study 5: Ruling Out Participant Deception

This study was also designed to reduce suspicions about participants' possible construction of responses to ensure favorable outcomes. If participants saw both interpretations and selectively reported the favorable interpretation, then both percepts in previous studies (e.g., horse vs. seal) would have to be accessible to them, in that participants would have to have seen both interpretations and selected only one when asked for an interpretation. To test this possibility, we again told participants that they were here to predict and describe taste sensations of freshly squeezed orange juice and organic veggie smoothie. They were shown an ambiguous figure, but before they could report what they had seen, the experimenter reported that he or she had made a mistake: that the participant would be assigned to the orange juice condition if the computer had shown him or her the other category of animal.

Of key importance was what interpretation participants would report: the one they desired at the time they viewed the ambiguous figure or the one desired at the time they had to report what they saw. If participants saw only one interpretation in consciousness as they viewed the figure and if that interpretation was influenced by their motivational state, they should be more likely to report the figure they desired at the time the figure was presented to them. However, if they saw both interpretations and just reported the one that was desired when the experimenter asked for their report, then they should more likely report the figure that ran counter to their desires at the time they viewed the figure.

[2] The effects and conclusions reported in the text remained virtually the same if we controlled for the specific words participants reacted to in the LDT. We should also note that all participants in a particular session, when multiple participants ran, were assigned to the same condition. Thus, although participants were assigned randomly, they were not assigned independently. This led cell sizes to differ somewhat. We should note that we ran supplemental analyses to gauge whether any of our results were due to session effects. When we controlled for the particular session in which participants ran (by conducting analyses in which session was added as a random variable nested within our conditions), we found our findings remained intact.

### Method

*Participants.* Participants were 27 undergraduates at Cornell University who received extra credit in their psychology courses for taking part.

*Procedure.* The procedures for this experiment were modeled closely on those used in Study 1. Again, the computer would assign the participant to drink freshly squeezed orange juice or an off-putting veggie smoothie on the basis of the single item that it randomly selected from a database. In this study, though, for half of the participants, if the computer displayed a farm animal, participants would consume the orange juice, whereas a sea creature would bring the veggie smoothie. For the other half of the participants, this was reversed. After these instructions were explained to participants, the experimenter supposedly calibrated the computer program. In a practice phase, the program displayed four animals as examples of what would be shown. Two of these examples were farm animals, and two were sea creatures. Crossed with this, two of the animals were drawings of the full bodies of animals, whereas two were just of animal heads.

Following the examples, participants fixated on a red dot flashing in the center of a 15-in. G3 iBook screen for 3 s. This fixation point was then replaced by the horse–seal ambiguous figure (3.75 in. high, 2.75 in. wide) displayed for 1,000 ms followed by the same staged computer program crash. The experimenter remained preoccupied with paperwork until the participant got her attention.

Unlike the previous study, the experimenter did not ask the participant at this point if anything was displayed before the crash. Instead, she immediately offered that the crash was most likely because she made an error during the calibration. For those participants for whom farm animals were valued, she continued by saying the error was that in fact sea creatures were supposed to signal the consumption of orange juice. For those valuing sea creatures, she said the error was that farm animals were in fact supposed to signal the consumption of orange juice. To rephrase, after the crash, the experimenter switched which animals were desired. After explaining this confusion and making the switch, the experimenter asked if anything was shown before the crash.

### Results

The procedure of Study 5 put two accounts for our data in opposition. Our guiding hypothesis is that participants' motivational states influence the interpretation of the ambiguous figure that is presented to consciousness at the time the figure is viewed. If motivational states help to disambiguate the figure during the time it is viewed, we would expect that after the switch participants would tend to report seeing the animal from the desired category at the time of viewing the object, even though this animal, after the switch in instructions, ultimately consigned them to drink the veggie smoothie. However, if participants see both interpretations and then just report the one that they favor, then we would expect that participants would be more likely to report seeing an animal from the category that is desirable after the switch.

We used the same type of coding scheme for interpretations as in the previous studies. Using an ordinal logistic regression, we found that participants were more likely to report the animal that was originally the most desired even when this meant they would complete the less desirable task, $\chi^2(1, N = 27) = 9.48$, $p = .002$. When participants originally hoped to see farm animals, 100% ($n = 13$) reported seeing a horse even when the horse ultimately meant drinking the veggie smoothie. When participants originally hoped to see sea creatures, 28.6% ($n = 4$) reported seeing a seal, 57.1% ($n = 8$) saw a horse, and 14.3% ($n = 2$) said nothing was shown before the crash. Focusing on only those participants reporting an interpretation, we again found that participants were more likely to report a horse or a seal when they were originally motivated to see that type of animal (Fisher's exact $p = .039$). Although a larger percentage of participants reported seeing a horse than they did a seal when originally hoping to see sea creatures, what is important is that the percentage who saw a seal is biased between conditions on the basis of original desire. That is, when originally hoping to see a horse, none saw a seal, but when originally hoping to see a seal, nearly 30% saw one.

## General Discussion

The world people know is the one they take in through their senses. In these studies, we examined the extent to which what people take in could be guided by such top-down constraints as personal wishes and preferences.

Across these studies, we provided converging evidence to suggest that participants' desires, hopes, fears, or wishful thinking led them to perceive a representation of the visual environment they desired. Studies 1 and 2 demonstrated that participants tended to interpret an ambiguous figure in a manner that fit with their wishes and preferences over one that did not. Studies 3 and 4 added implicit measures to ensure that participants actually saw the interpretation they favored and not just what they chose to report seeing. Specifically, for a clear majority of participants in Study 3, their first saccade after presentation of an ambiguous stimulus tended to be to the favored category label rather than to the disfavored one. In Study 4, after viewing an ambiguous figure, participants reacted in an LDT to words consistent with a preferred interpretation more quickly than to words consistent with the less preferred one. It is important that this facilitation after seeing the ambiguous stimulus was greater than it was for those performing the LDT before viewing the stimulus, indicating that the ambiguous figure primed concepts associated with the preferred interpretation more than it did the less preferred one.

Study 5 added a procedural variation to affirm that participants did not see both interpretations in our experiments and then just report the one that brought about the favored outcome. Participants viewed an ambiguous stimulus while hoping for one outcome, but then the experimenter switched which interpretation was the favored one before participants reported what they had seen. Participants tended to report seeing the interpretation they favored at the time they viewed the stimulus, even though that report, after the switch, assigned them to a less desired task. It is important that Study 5 demonstrated that wishful thinking constrains perceptual processes preconsciously, before the products of those processes become available to conscious awareness.

### Alternative Accounts

A critic might argue that the paradigms we used might have taken advantage of other psychological processes, rather than motivational states, that could influence participants' interpretation of ambiguous stimuli. For example, participants' interpretations of ambiguous figures could have been due to differences in expectation. In Studies 2, 3, and 4, participants were exposed to a series of stimuli they did not want to see just before they viewed the critical ambiguous stimulus. Participants' might have fallen prey to the gambler's fallacy and expected that a favored animal was bound to show up after a string of unwanted ones.

However, Study 1, the control study associated with Study 2, and Study 5 all argue against this explanation. For example, Studies 1 and 5 presented participants with a single stimulus and still found that people tended to see the interpretation they wanted to see over the one they did not. In addition, the control study associated with Study 2 specifically tested whether a gambler's fallacy alone would influence what they saw in the ambiguous figure when participants had no motivation to interpret the ambiguous figure in a certain way.

Further, it is implausible that our results are explained by cognitive or perceptual salience. That is, one could argue that the desired interpretation was highlighted and more easily seen by participants because that perceptual outcome was paired with a desirable event. However, in our experiments we were careful to pair both the favored and less favored interpretations with salient events. In Study 1, for example, seeing a number might be associated with drinking delicious orange juice, but seeing a letter was associated with an event—drinking a foul-smelling and foul-looking concoction—that was at least as salient. Thus, salience is not a viable alternative explanation for the pattern of responses we observed.

### *Notes on the Mechanism Underlying Biased Perception*

Our results suggest that people's desires for a particular outcome bias their perceptual set, such that they are more prepared to see what they hope for rather than what they fear. In fact, in a funneled probe for suspicion, one participant offered, "I kept getting +5 and –5 over and over, making me worry about eating the beans. At the last minute, I was sure I would have to eat the heinous beans and I prayed for the horse to give me a +5. I got it! Yes!" Of course, prayer may not always be the precise mechanism biasing all participants' interpretations, but we do feel this illustrates a possible chain of events leading to differences in what participants saw. A desire to see one stimulus over the other led to the formation of a perceptual set that included features and concepts related to the desired stimulus over the undesired one. Indeed, in Study 4, we discovered initial evidence of a perceptual set biased toward the favored hypothesis. Just before viewing the ambiguous stimulus, participants were slightly—but significantly—faster at recognizing words associated with the favored interpretation than they were words associated with the disfavored interpretation.

Two notes are in order concerning this finding and the potential role of perceptual set in motivational influences on perception. First, the specific perceptual hypothesis that participants might be using to disambiguate the stimulus need not be closely tied to the nature of the stimulus. To be sure, in Studies 2, 3, and 4, participants were given a rather narrow hypothesis (i.e., the desirable stimulus will be either a horse or a seal) about what the computer might show them. In this way, our work is reminiscent of previous work concerning contextual effects on visual perception of ambiguous figures, in which participants are given primes whose appearance is quite close to that of the ambiguous stimulus (i.e., they are shown drawings of women) before they view that stimulus (e.g., one seen as either a man or woman; Long & Toppino, 2004). However, in Studies 1 and 5, participants were not given such specific hints about what the stimulus might be. Instead, they were given broad categories (e.g., a letter versus a number; a farm versus a sea animal). As a result, they were not necessarily able to look for features of a specific stimulus but rather had to search for any number of possible stimuli to satisfy these broad categories. Even in this circumstance, participants tended to see what they wanted to see. This suggests that the top-down influences on perception inspired by motivation can be quite diffuse and nonspecific: that when disambiguating an ambiguous figure, people do not need concrete features specified a priori. Instead, the clues or context surrounding the perceptual judgment can be quite vague, indirect, abstract, or higher order. This conjecture is consistent with other recent evidence showing that priming people with abstract categories (such as "flirting" or "music") has an impact on how they interpret ambiguous figures they subsequently view (see Balcetis & Dale, 2003).

Second, these studies left open one ambiguity about perceptual set that future work could profitably address. Across five studies, we found that people tended to see an interpretation they favored over one they did not. But did this bias arise because the perceptual set associated with their motivational state was an *approach* one, facilitating processes associated with seeing the favored interpretation, or an *avoidance* one, inhibiting processes that could lead them to see the disfavored interpretation? Either route—facilitation of the favored interpretation, inhibition of the disfavored one, or a mixture of the two—could lead to the pattern of responses we observed. Future work could potentially tease apart whether the phenomenon we uncovered is one in which people are biased toward seeing wanted stimuli or biased against seeing stimuli they wish to avoid, or both.

### *Where Does the Bias Reside in the Perceptual System?*

One remaining question that this work leaves open is determining the stage in the perceptual process at which motivational factors begin to guide perception. Such a question is relevant not only to work on motivation but also to work on other higher order constructs (e.g., stereotypes, expectations, frames) that have been at the focus of social cognitive work. Is the impact of motivation limited to later stages of perception, such as categorization, or does its influence extend to earlier and more primitive tasks the perceptual system faces (e.g., noticing lines and edges in a visual scene)?

This question became a major theoretical battle during the New Look period, one that continues to this day. In particular, Bruner and Goodman's (1947) theory of perceptual defense was criticized by opponents, who asked how a perceiver could selectively defend against a particular stimulus unless the stimulus is already perceived (Eriksen & Browne, 1956; Howie, 1952; Spence, 1967). Critics of Bruner and Goodman (1947) and more recent ones have argued that higher order constraints influence not early perception but rather later stages of the perceptual processes that could be termed *postperceptual* or *perceptual decision making*. Pylyshyn (1999), for example, asserted that the act of perceiving an object contains at least two processes. One process, termed *early vision works*, which is immune to higher order influences, works to provide three-dimensional representations of the surfaces of objects. A later process takes any created representation and then identifies or categorizes it. Pylyshyn (1999) argued that higher order influences have an impact predominantly on this latter stage.[3]

However, this assertion is a contentious issue (see the commentaries that accompany Pylyshyn, 1999), and more recent evidence suggests that higher order processes can impose their influence on perception very early in the perceptual process. Emerging evidence, for example, suggests that higher order influences can be detected in V1, the area of the primary visual cortex considered to be the simplest, earliest cortical visual area responsible for processing visual stimuli, which is a mere two synapses away from the eye (Boynton, 2005). For example, when perceivers are asked attend to one of two overlapping orthogonal line patterns, functional magnetic resonance imaging activity patterns in early visual areas, including V1, contain information that can predict what the participant consciously perceives (Kamitani & Tong, 2005). Perceptions of patterns in V1 also occur even if participants are clearly unaware that a pattern has been shown to them (Haynes & Rees, 2005).

### *Implications for Self-Deception*

The data from these five studies also have implications for another enduring issue in psychology. Over the decades, social, personality, clinical, and cognitive psychologists have catalogued a myriad of ways in which people engage in wishful thinking (for reviews, see Baumeister & Newman, 1994; Dunning, 2001; Kunda, 1990; Mele, 1997; Pittman, 1998). However, people remain seemingly unaware that they do all this cognitive work; they remain innocent of the fact that their fears and desires have shaped how they view themselves and think about the world around them (Ehrlinger, Gilovich, & Ross, 2005; Gilbert, Pinel, Wilson, Blumberg, & Wheatley, 1998; Mele, 1997; Pronin, Gilovich, & Ross, 2004).

Indeed, for people to reach their motivational goals, it is imperative that they remain unaware of the distortions they place on their thinking. If they knew that they believed some pleasant thought merely because they wanted to believe it, they would also know, at least in part, how illegitimate that thought was. How, then, do people pull off the self-deception crucial to the execution of motivated reasoning?

Our data provide one answer to this riddle. People fail to recognize such self-serving biases if those processes remain outside of conscious awareness, monitoring, or control. If those processes take place preconsciously, before any content of perception and cognition reaches consciousness, people can construct pleasant thoughts yet remain unaware of the construction. The only content that would be available in consciousness would be the product and not the process of motivated reasoning. There exist some shards of evidence that motivational processes operate on a nonconscious level (e.g., Arndt, Greenberg, Pyszczynski, & Solomon, 1997; Fein & Spencer, 1997). The present studies enlarge the types of nonconscious processes that motivational states may influence, and it may be profitable to consider other automatic or nonconscious processes that might be molded, in part, by the motivation toward believing in a masterful self in a congenial world.

One also wonders about the full range of nonconscious processes that might be tainted by motivational pressures. The world people know is the one they take in through their senses, but it is also formed by other preconscious processes. To what extent is the representation of the world furnished to conscious awareness by all of these processes one that reproduces the outside world faithfully versus one that people just wish they could inhabit? There is much work to be done to address this question, and we are unsure at the end what picture of the perceiver we will see.

[3] Pylyshyn (1999) also allowed for the possibility that higher order processes might guide attentional mechanisms that guide early vision.

## References

Aarts, H., & Dijksterhuis, A. (2002). Category activation effects in judgment and behaviour: The moderating role of perceived comparability. *British Journal of Social Psychology, 41,* 123–138.

Adkins, L. J. (1956). Critical comment on the measurement of familiarity in personality-perception experiments. *Perceptual and Motor Skills, 6,* 147–151.

Allopenna, P. D., Magnuson, J. S., & Tanenhaus, M. K. (1998). Tracking the time course of spoken word recognition using eye movements: Evidence for continuous mapping models. *Journal of Memory and Language, 38,* 419–439.

Allport, A. (1989). Visual attention. In M. I. Posner (Ed.), *Visual attention* (pp. 631–682). Cambridge, MA: The MIT Press.

Arndt, J., Greenberg, J., Pyszczynski, T., & Solomon, S. (1997). Subliminal exposure to death-related stimuli increases defense of the cultural worldview. *Psychological Science, 8,* 379–385.

Baird, J. C., & Biersdorf, W. R. (1967). Quantitative function for size and distance judgments. *Perception & Psychophysics, 2,* 161–166.

Balcetis, E., & Dale, R. (2003). There is no naked eye: Higher-order social concepts clothe visual perception. *Proceedings of the twenty-fifth annual meeting of the Cognitive Science Society* (pp. 109–114). Mahwah, NJ: Erlbaum.

Baumeister, R. F., & Newman, L. S. (1994). Self-regulation of cognitive inference and decision processes. *Personality and Social Psychology Bulletin, 20,* 3–19.

Bhalla, M., & Proffitt, D. R. (1999). Visual–motor recalibration in geographical slant perception. *Journal of Experimental Psychology: Human Perception and Performance, 25,* 1076–1096.

Biederman, I., Mezzanotte, R. J., & Rabinowitz, J. C. (1982). Scene perception: Detecting and judging objects undergoing relational violations. *Cognitive Psychology, 14,* 143–177.

Boyce, S. J., & Pollatsek, A. (1992). Identification of objects in scenes: The role of scene background in object naming. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18,* 531–543.

Boynton, G. M. (2005). Imagining orientation selectivity: Decoding conscious perception in V1. *Nature Neuroscience, 8,* 541–542.

Bruner, J. S., & Goodman, C. C. (1947). Value and need as organizing factors in perception. *Journal of Abnormal Social Psychology, 42,* 33–44.

Bruner, J. S., & Minturn, A. L. (1955). Perceptual identification and perceptual organization. *Journal of General Psychology, 53,* 21–28.

Bugelski, B. R., & Alampay, D. A. (1961). The role of frequency in developing perceptual sets. *Canadian Journal of Psychology, 15,* 205–211.

Changizi, M. A., & Hall, W. G. (2001). Thirst modulates a perception. *Perception, 30,* 1489–1497.

Creem, S. H., & Proffitt, D. R. (1998). Two memories for geographical slant: Separation and interdependence of action and awareness. *Psychonomic Bulletin & Review, 5,* 22–36.

Darlington, R. B., & Hayes, A. F. (2000). Combining independent *p*-values: Extensions of the Stouffer and binomial methods. *Psychological Methods, 5,* 496–515.

Dawson, E., Gilovich, T., & Regan, D. T. (2002). Motivated reasoning and performance on the Wason selection task. *Personality and Social Psychology Bulletin, 28,* 1379–1387.

Ditto, P. H., & Lopez, D. F. (1992). Motivated skepticism: Use of differential decision criteria for preferred and nonpreferred conclusions. *Journal of Personality and Social Psychology, 63,* 568–584.

Dunning, D. (2001). On the motives underlying social cognition. In N. Schwarz & A. Tesser (Eds.), *Blackwell handbook of social psychology: Vol. 1. Intraindividual processes* (pp. 348–374). New York: Blackwell.

Durgin, F. H., Proffitt, D. R., Olson, T. J., & Reinke, K. S. (1995). Comparing depth from motion with depth from binocular disparity. *Journal of Experimental Psychology: Human Perception and Performance, 21,* 679–699.

Ehrlinger, J., Gilovich, T., & Ross, L. (2005). Peering into the bias blind spot: People's assessment of bias in themselves and others. *Personality and Social Psychology Bulletin, 31,* 680–692.

Erdelyi, M. H. (1974). A new look at the new look: Perceptual defense and vigilance. *Psychological Review, 81,* 1–25.

Erdelyi, M. H. (1985). *Psychoanalysis: Freud's cognitive psychology.* New York: Freeman.

Eriksen, C. W. (1958). Unconscious processes. In M. R. Jones (Ed.), *Nebraska symposium on motivation* (pp. 169–227). Lincoln: University of Nebraska Press.

Eriksen, C. W. (Ed.). (1962). *Behavior and awareness: A symposium of research and interpretation.* Durham, NC: Duke University Press.

Eriksen, C. W., & Browne, C. T. (1956). An experimental and theoretical analysis of perceptual defense. *Journal of Abnormal and Social Psychology, 52,* 224–230.

Fein, S., & Spencer, S. J. (1997). Prejudice as self-image maintenance: Affirming the self through derogating others. *Journal of Personality and Social Psychology, 73,* 31–44.

Fisher, G. H. (1968). Ambiguity of form: Old and new. *Perception & Psychophysics, 4,* 189–192.

Gilbert, D. T. (1998). Ordinary personology. In D. T. Gilbert, S. Fiske, and G. Lindzey (Eds.), *Handbook of social psychology* (Vol. 2, pp. 89–150). New York: McGraw-Hill.

Gilbert, D. T., Pinel, E. C., Wilson, T. D., Blumberg, S. J., & Wheatley, T. P. (1998). Immune neglect: A source of durability bias in affective forecasting. *Journal of Personality and Social Psychology, 75,* 617–638.

Gilinsky, A. S. (1951). Perceived size and distance in visual space. *Journal of Experimental Psychology, 44,* 11–15.

Goldiamond, I. (1958). Indicators of perception: I. Subliminal perception, subception, unconscious perception: An analysis in terms of psychophysical indicator methodology. *Psychological Bulletin, 55,* 373–411.

Greenwald, A. G. (1992). New look 3: Unconscious cognition reclaimed. *American Psychologist, 47,* 766–779.

Gregory, R. L. (1974). Choosing a paradigm for perception. In E. C. Carterete & M. P. Friedman (Eds.), *Handbook of perception: Vol. 1. Historical and philosophical roots of perception* (pp. 255–283). New York: Academic Press.

Haynes, J.-D., & Rees, G. (2005). Predicting the orientation of invisible stimuli from activity in human primary visual cortex. *Nature Neuroscience, 8,* 686–691.

Henderson, J. M., & Hollingworth, A. (1999). High-level scene perception. *Annual Review of Psychology, 50,* 243–271.

Howes, D. H., & Solomon, R. L. (1950). A note on McGinnies' "emotionality and perceptual defense." *Psychological Review, 57,* 229–234.

Howie, D. (1952). Perceptual defense. *Psychological Review, 59,* 308–315.

Johnston, L., Arden, K., Macrae, C. N., & Grace, R. C. (2003). The need for speed: The menstrual cycle and person construal. *Social Cognition, 21,* 89–100.

Jones, E. E. (1985). Major developments in social psychology during the past five decades. In G. Lindzey & E. Aronson (Eds.), *The handbook of social psychology* (3rd ed., Vol. 1, pp. 47–108). New York: Random House.

Kamitani, Y., & Tong, F. (2005). Decoding the visual and subjective contents of the human brain. *Nature Neuroscience, 8,* 679–685.

Kosslyn, S. M., & Koenig, O. (1992). *Wet mind: The new cognitive neuroscience.* New York: Free Press.

Kunda, Z. (1990). The case for motivated reasoning. *Psychological Bulletin, 108,* 480–498.

Langer, E. J., & Abelson, R. P. (1972). The semantics of asking a favor: How to succeed in getting help without really dying. *Journal of Personality and Social Psychology, 24,* 26–32.

Leeper, R. (1935). A study of a neglected portion of the field of learning—The development of sensory organization. *Journal of Genetic Psychology, 46,* 41–75.

Li, L., & Warren, H. (2004). Path perception during rotation: Influence of instructions, depth range, and dot density. *Vision Research, 44,* 1879–1889.

Loach, D., & Mari-Beffa, P. (2003). Post-target inhibition: A temporal binding mechanism? *Visual Cognition, 10,* 513–526.

Long, G. M., & Olszweski, A. D. (1999). To reverse or not to reverse: When is an ambiguous figure not ambiguous? *American Journal of Psychology, 112,* 41–71.

Long, G. M., & Toppino, T. C. (2004). Enduring interest in perceptual ambiguity: Alternating views of reversible figures. *Psychological Bulletin, 130,* 748–768.

Macrae, C. N., Alnwick, K. A., Milne, A. B., & Schloerscheidt, A. M. (2002). Person perception across the menstrual cycle: Hormonal influences on social–cognitive functioning. *Psychological Science, 13,* 532–536.

McCurdy, H. G. (1956). Coin perception studies and the concept of schemata. *Psychological Review, 63,* 160–168.

Mele, A. R. (1997). Real self-deception. *Behavioral and Brain Sciences, 20,* 91–136.

Meng, M., & Tong, F. (2004). Can attention selectively bias bistable perception? Differences between binocular rivalry and ambiguous figures. *Journal of Vision, 4,* 539.

Michelon, P., & Koenig, O. (2002). On the relationship between visual imagery and visual perception: Evidence from priming studies. *European Journal of Cognitive Psychology, 14,* 161–184.

Miller, J. (1987). Priming is not necessary for selective-attention failures: Semantic effects of unattended, unprimed letters. *Perception and Psychophysics, 41,* 419–434.

Neely, J. H. (1991). Semantic priming effects in visual word recognition: A selective review of current findings and theories. In G. W. Humphreys & D. Besner (Eds.), *Basic processes in reading: Visual word recognition* (pp. 264–336). Hillsdale, NJ: Erlbaum.

Nisbett, R. E., & Ross, L. D. (1980). *Human inference: Strategies and shortcomings of social judgment.* Englewood Cliffs, NJ: Prentice Hall.

Pelli, D., Palomares, M., & Majaj, N. J. (2004). Crowding is unlike ordinary masking: Distinguishing feature integration from detection. *Journal of Vision, 4,* 1136–1169.

Pittman, T. S. (1998). Motivation. In D. Gilbert, S. Fiske, & G. Lindsay (Eds.), *Handbook of social psychology* (4th ed., Vol. 1, pp. 549–590). Boston: McGraw-Hill.

Postman, L., Bruner, J. S., & McGinnies, E. (1948). Personal values as selective factors in perception. *Journal of Abnormal and Social Psychology, 43,* 142–154.

Prentice, W. C. H. (1958). Perception. *Annual Review of Psychology, 9,* 1–18.

Proffitt, D. R., Creem, S. H., & Zosh, W. (2001). Seeing mountains in mole hills: Geographical slant perception. *Psychological Science, 12,* 418–423.

Proffitt, D. R., Stefanucci, J., Banton, T., & Epstein, W. (2003). The role of effort in perceiving distance. *Psychological Science, 14,* 106–112.

Pronin, E., & Gilovich, T., & Ross, L. (2004). Objectivity in the eye of the beholder: Divergent perceptions of bias in self versus others. *Psychological Review, 111,* 781–799.

Pylyshyn, Z. W. (1999). Is vision continuous with cognition? The case for cognitive impenetrability of visual perception. *Behavioral and Brain Sciences, 22,* 341–423.

Pyszczynski, T., & Greenberg, J. (1987). Toward an integration of cognitive and motivational perspectives on social inference: A biased hypothesis-testing model. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 20, pp. 297–340). New York: Academic Press.

Raymond, J. E., Shapiro, K. L., & Arnell, K. M. (1992). Temporary suppression of visual processing in an RSVP task: An attentional blink? *Journal of Experimental Psychology: Human Perception and Performance, 18,* 849–860.

Richardson, D. C., & Spivey, M. J. (2000). Representation, space and Hollywood Squares: Looking at things that aren't there anymore. *Cognition, 76,* 269–295.

Rock, I., & Mitchener, K. (1992). Further evidence of failure of reversal of ambiguous figures by uninformed subjects. *Perception, 21,* 39–45.

Sanitioso, R., Kunda, Z., & Fong, G. T. (1990). Motivated recruitment of autobiographical memories. *Journal of Personality and Social Psychology, 59,* 229–241.

Simons, D. J., & Chabris, C. F. (1999). Gorillas in our midst: Sustained inattentional blindness for dynamic events. *Perception, 28,* 1059–1074.

Spence, D. P. (1967). Subliminal perception and perceptual defense: Two sides of a single problem. *Behavioral Science, 12,* 183–193.

Tanenhaus, M. K., Spivey-Knowlton, M. J., Eberhard, K. M., & Sedivy, J. C. (1995, June 16). Integration of visual and linguistic information in spoken language comprehension. *Science, 268,* 1632–1634.

Tittle, J. S., Todd, J. T., Perotti, V. J., & Norman, J. F. (1995). Systematic distortion of perceived three-dimensional structure from motion and binocular stereopsis. *Journal of Experimental Psychology: Human Perception and Performance, 21,* 663–678.

Todd, J. T., & Bressan, P. (1990). The perception of 3-dimensional affine structure from minimal apparent motion sequences. *Perception & Psychophysics, 48,* 419–430.

Todd, J. T., & Norman, J. F. (1991). The visual perception of smoothly curved surfaces from minimal apparent motion sequences. *Perception & Psychophysics, 50,* 509–523.

Toppino, T. (2003). Reversible-figure perception: Mechanisms of intentional control. *Perception & Psychophysics, 65,* 1285–1295.

Trope, Y., & Ferguson, M. J. (2001). How and when preferences influence inferences: A motivated hypothesis-testing framework. In J. Bargh & D. K. Apsley (Eds.), *Unraveling the complexities of social life: A Festschrift in honor of Robert B. Zajonc* (pp. 111–130). Washington, DC: American Psychological Association Press.

Wegner, D. M., & Bargh, J. A. (1998). Control and automaticity in social life. In D. Gilbert, S. T. Fiske, & G. Lindzey (Eds.), *Handbook of social psychology* (4th ed., Vol. 1, pp. 446–496). New York: McGraw-Hill.

Wohlwill, J. F. (1966). Perceptual learning. *Annual Review of Psychology, 17,* 201–232.

Yang, T. L., Dixon, M. W., & Proffitt, D. R. (1999). Seeing big things: Overestimation of heights is greater for real objects than for objects in pictures. *Perception, 28,* 445–467.

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