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Conceptual set as a top – down constraint on visual object identification

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Abstract. Four studies are reported which demonstrate that indirectly, loosely related information, otherwise known as conceptual set, modulates object identification. Studies 1A and 1B demonstrate the impact of indirect, nonspecific, non-perceptual, conceptual primes on the interpretation of ambiguous visual figures. Study 2 demonstrates that indirect, conceptual information (category of farm animals) biases identification without requiring the activation of direct perceptual information (here the image of a horse). Study 3 uses a non-linguistic dependent measure to address the alternative explanation that language and not perception mediates the relationship between incidental conceptual prime and biased object identification. These results suggest that conceptual set constrains object identification.

1 Introduction

The visual system informs organisms about objects in their surroundings, but how does it parse, process, and decode the vast quantity of information offered by a quick look at an object? To be sure, the perceptual system inevitably relies upon 'bottom – up' information to identify objects in the environment. Bottom – up constraints include basic components of objects (Kosslyn and Koenig 1992; Michelon and Koenig 2002), focal areas, critical features (Long and Olszweski 1999), fixation points (Meng and Tong 2004; Toppino 2003), and spatial proximity or 'crowding' (Pelli et al 2004), among others.

Nevertheless, growing research over the past half-century shows that visual perception is not purely a bottom – up process. Although it is a common intuition that the visual system incorporates basic units of information it extracts immediately to reach perceptual conclusions that reliably reconstruct the external world (eg Pylyshyn 1998), this thesis is subject to ongoing debate (eg see Edelman 1994, 1998). Rather than proposing that the information in the retinal array is sufficient to produce a single stable visual experience, a wealth of empirical work demonstrates that top – down processes impinge upon the processing of these local features to bias object identification (Ishikane 2003; Long and Toppino 2004; Rock 1975). Perception is systematically malleable, dependent upon the global influence of multiple higher-order, top – down constraints (Long and Toppino 2004).

These sources of top – down influence are quite varied and include such external influences on perception as characteristics of the environment or visual context. For example, the coherence of backgrounds impacts the speed with which objects embedded in that scene are identified (Boyce and Pollatsek 1992; Boyce et al 1989) and the accuracy of their identification (Biederman et al 1982). In addition, internal states of the perceiver alter perception. Women, during periods of high fertility, as opposed to low, were faster to identify men rather than women in photographs (Macrae et al 2002).

In this paper, we expand the spectrum of top – down constraints that are known to influence object identification. Research on the influence of top – down constraints

is well founded, dating back to James (1890), and continuing through the decades that followed. In particular, New Look researchers (Bruner 1957) of the 1940s and 1950s proposed that perception is filtered and biased by top–down influences—that the representation of the environment that people form omits or systematically alters a good deal of information (Allport 1989; Miller 1987).

However rich the history, we argue that an important distinction should be made between previous examinations of such effects and a largely underexplored component of this general, top–down perspective. Previous work on object identification focused on the influences of direct perceptual set. However, we provide evidence that conceptual information only incidentally associated with the perceived visual information constrains object identification. Informational sets need not be perceptual in nature or explicitly direct attention through instruction to bias the resolution of novel visual ambiguity. In doing so, we hope to address a few issues that led to the questioning of the conclusions drawn by our theoretical predecessors who proposed similar theses.

1.1 *Perceptual and conceptual set*

Perceptual set is a specific form of situational context that involves specific, highly related, directly relevant information immediately descriptive of the target object that has the potential to influence visual processing. This direct perceptual information can modulate interpretations of an object with more than one possible resolution. For example, Bugelski and Alampay (1961; see also Crandall and de Lissovoy 1977) provided classic examples of perceptual-set effects in which prior exposure to pictures of animals or human faces biased interpretation of the rat/man ambiguous figure. Similarly, Epstein and Rock (1960) biased interpretations of the young/old woman figure by exposing participants beforehand to less ambiguous versions of the same figure.

Distinct from this past work, the current research expands the definition of perceptual set to investigate the role of what may be termed conceptual set. We define conceptual set as incidental, loosely related information that is not perceptual in nature, but that is effective in subtly guiding the perceptual system during object identification. For instance, relative spatial positioning is a type of conceptual set that biases object identification. Bar and Ullman (1996) showed participants pairs of objects that were either in the correct relative spatial positions (eg a hat above a leg) or in incorrect relative positions (eg a leg above a hat). Participants more accurately and more quickly identified the objects when the objects satisfied the correct position relation than when they violated it. Additionally, adult attachment styles can change the identification of other people's emotional states (Niedenthal et al 2002). For example, fearfully attached individuals are faster to see a happy facial expression change to a neutral one than are individuals with other attachment styles.

1.2 *Historical basis*

Although interest in conceptual set effects has been raised in the past, attempts to make such a distinction at various points throughout the preceding decades were inconclusive. New Look researchers suggested that as perceivers we "go beyond the information given" (Bruner 1957). However, the specific claim that conceptual set, as we have defined it, biases perception was never firmly established for many reasons. Among other concerns, New Look research and other work that followed conflated (i) perceptual and conceptual biasing information and (ii) the measurement of memory and perception (Dunning 2001; Erdelyi 1974; Gilbert 1998; Jones 1985; Nisbett and Ross 1980).

First, the 'set' that previous work established frequently employed specific, perceptual information directly related to one of the two interpretations of the ambiguous figure. That is, supporting literature demonstrated top–down influences with visual images but in doing so suggested perceptual resolutions to the ambiguity. For instance,

Leeper (1935) exposed participants to a simplified version of Boring's (1930) young/old woman ambiguous figure that emphasized characteristics of either the young or old woman. These disambiguated figures biased subsequent identification of the original truly ambiguous figure such that participants reported an interpretation that was congruent with their prior visual experience (see also Fisher 1967). Seeing a visual image of a young woman increased the likelihood that observers saw the young woman in the ambiguous figure, yet the prime employed was directly descriptive, perceptual information.

Second, previous demonstrations of conceptual set may activate linguistic labels for one of the possible interpretations of the figure. For instance, it is unclear given Leeper's (1935) paradigm whether or not viewing a visual image of a young woman made accessible the label "young woman". Activating a linguistic description of a young woman may have increased the likelihood of a young woman resolution of the figure. Although suggestive, we argue that this biasing information did not satisfy the criteria for conceptual set. These verbal descriptions activated perceptual sets by providing direct labels or responses for the very specific perceptual conclusions the primed sets were expected to induce. That is, the inclusion of the words "young woman" in the priming narrative offered perceivers a label for a specific perceptual resolution of the ambiguous figure.

Beyond labeling, there is another way in which the existing literature conflated perceptual and conceptual constraints. Previous work did not control the amount of exposure observers had to visual information that would bias resolution of visual ambiguity. For instance, in suggesting techniques for demonstrating priming effects in visual ambiguity resolution, guides for classroom demonstration (eg Bernstein and Nash 1991) do not ask nor would it be feasible for instructors to tightly control the amount of exposure students receive to either the prime or stimulus. A similar concern pervades empirical tests; Brugger and Brugger (1993) asked people as they entered a zoo in either October or at Easter to describe the contents of a picture. Participants saw an ambiguous line drawing that could be interpreted as either a bird of some sort or a rabbit. The drawing, though perceived as a bird by the majority in October, was more often described as a rabbit when participants were asked at Easter. Although the authors argued that expectancies surrounding these testing dates biased interpretations of the figure, it is likely that participants' visual exposure to images of rabbits surrounding the Easter holiday was greater than exposure to the same animal in October. That is to say, it might be the case that conceptual information led to perceptual bias. However, it is possible that perceptual sets and direct visual information suggested an interpretation consistent with the holiday theme. Simply put, people are more likely to be exposed to visual images and actual figures of rabbits like the Easter bunny at and before Easter in comparison to other days of the year.

Outside of conflating perceptual and conceptual primes, previous researchers were unable to separate effects on memory and previous experience from effects on perception. 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. Bruner argued that children of lower socioeconomic status, for whom the value of money was greater, overestimated the size of the coins compared with children of higher socioeconomic status who were presumed to place less value on the same coins. However, to claim conceptual set alone biased perception on the basis of this type of data is difficult. For instance, children of less affluent families might misjudge the size of coins because they were not as familiar with them, or that their misjudgments varied as a function of accuracy in memory for the coins and previously made estimates rather than current perceptions of coin size (McCurdy 1956).

Thus, previous work on object identification focused on the influences of direct perceptual set. Work which investigated indirect influences conflated memory with perception and did not control for past experience with the target objects. Underrepresented are demonstrations that conceptual information only remotely related to the possible interpretations of the target object can constrain novel object identification. We contend that informational sets need not be perceptual in nature, do not need to take the form of direct visual priming, or explicitly use attention to bias the resolution of visual ambiguity not before experienced by the perceiver. Thus, we aimed to conduct a more controlled and rigorous test of the effects of conceptual set than would be possible in a class demonstration or have been demonstrated previously.

Objects, like much of the contents of our surroundings, lack clarity and can usually be interpreted in multiple ways; how that ambiguity is resolved is determined by a number of processes. Although the possible processes by which ambiguity is resolved are numerous, we propose that conceptual set in particular might influence ambiguous object identification through selective attention. Selective attention can facilitate object identification by directing the visual system toward focal elements of the ambiguous visual information that might constrain identification (see Yantis 1996). Attended elements that are congruent with the conceptual prime might be processed prior to other elements or to a greater extent than those elements that are incongruent with the conceptual prime. These attended elements might be matched against internally stored representations of objects contained in the conceptual set (Long and Toppino 2004). These representations can be considered 'templates' that provide a competitive advantage for interpretations of the ambiguous figure that are congruent with the conceptual set. That is, we propose that conceptual sets influence object identification by activating broad interrelated associations of features contained within the set. These associations or schemas (Bartlett 1935) filter and bias perception by directing attention quickly and efficiently to elements of the ambiguous figure that are focal to a specific interpretation congruent with the conceptual prime.

1.3 *Overview of experiments*

In the following experiments, we demonstrate that the activation of conceptual set systematically biases the interpretation of ambiguous visual stimuli. Additionally, these demonstrations suggest that it is not necessary to use attention to privilege perceptual information specific to one possible interpretation. Broadly speaking, perceptual biases can proceed largely unconsciously, without direct or immediate mediation of perceptual information or biased attention. The incidental nature of the primes suggests that broader conceptual information interacts with the processing of visual stimuli, further strengthening an interactive perspective on object identification. Although other researchers laid the theoretical framework for such a perspective, we hope to address a few of the issues that left them unable to firmly conclude that incidental conceptual information constrains object identification.

Studies 1A and 1B demonstrate the role of conceptual set in object identification. In addition, these experiments examine a number of parameters involved in object identification, including the nature of the ambiguous, visual objects and the modulation of strongly favored percepts. Study 2 increases the variability of the conceptual prime by allowing self-generation within the priming paradigm. In addition, this study tests the relative contributions of conceptual and perceptual set on identification. Study 3 uses a non-linguistic dependent measure to address the alternative explanation that language and not perception mediates the influence of the incidental conceptual prime and biased object identification. Each successive demonstration reveals that conceptual set influences object identification.

2 Study 1A

Study 1A demonstrates the effects of indirect, language-induced cues on identification of visual information with more than one interpretation.

2.1 *Method*

Fifty-eight Cornell undergraduates evaluated the text and pictures of one of two fictitious children's books. While seated individually in front of a 17-inch monitor connected to a G3 Macintosh computer in a well-lit cubicle, approximately half of the participants ($n = 32$) were randomly assigned to read 5 paragraphs briefly describing Henry Ford, the history of the automobile, and the need for regulation of automobiles on the road. The other half of participants ($n = 26$) were randomly assigned to read 5 paragraphs outlining a brief history of a few astronauts and their space exploration. Conceptual priming paragraphs in this and subsequent studies were equated for length. In addition, no paragraph mentioned a direct label for the possible interpretations of the ambiguous figure. For instance, 'signs' were not mentioned in the Ford paragraph.

Immediately following the paragraphs, all participants judged the appropriateness of a few photos for inclusion in such a children's book. The first 3 photographs presented on the computer screen were all unrelated to both automobile and space history and included a Ferris wheel, ice cream stand, and an abstract art painting. Participants wrote a one or two sentence description of the photograph on their paper response sheet and made judgments about the appropriateness of such photos for inclusion in the children's book to uphold the cover story. After the 3 filler photos but before 3 more thematically irrelevant filler photos, participants were shown the photograph in figure 1 (Seckel 2002; 4 inches tall $\times$ 5 inches wide) for 1000 ms.[(1)] As they had done with the 3 filler photos that preceded the target photo, participants wrote down a one or two sentence description of the target photo before judging its appropriateness for inclusion in the book. After completing this task, participants were probed for suspicion of the true purpose of the study. That is, participants completed a questionnaire that asked them to describe the purpose of the study in general and how the different components of the task were related to one another.

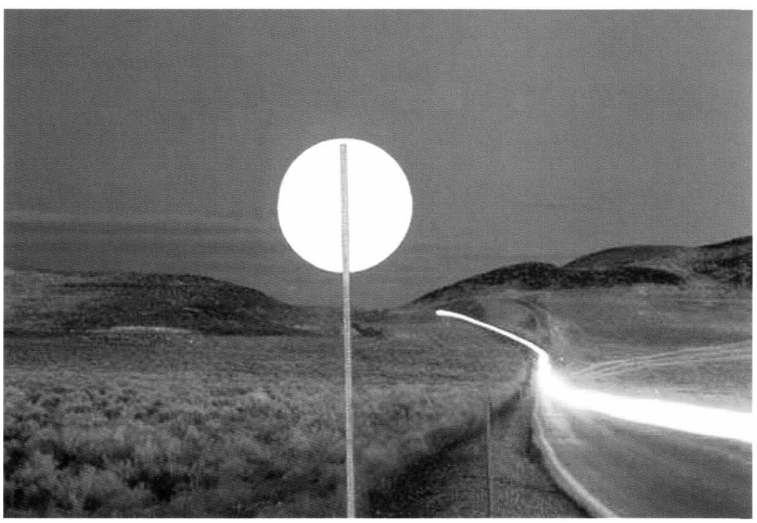

Figure 1. Photograph that includes a sign/moon ambiguous object.

[(1)] In this and all additional studies, lesser-known ambiguous figures were chosen that are approximately equi-biased. However, all the figures in this paper have one interpretation that is favored over the other. Thus, our manipulations are intended simply to establish top–down contexts that modulate this bias.

No participant stated that we were interested in seeing how their interpretation of the figure would be influenced by what they read beforehand.

2.2 *Results and discussion*

2.2.1 *Coding scheme.* A research assistant blind to condition coded written descriptions of the ambiguous photograph. Reports of a sign received a score of +1. Reports of a sun or moon received a score of −1. Those that did not clearly indicate their interpretation of the ambiguous object (eg desert scene) received a score of 0 ($n = 12$).

2.2.2 *Object identification.* Of interest was the description participants provided of the light circle in the center of the photo. We expected that a greater proportion of participants would report seeing the back of a road sign after reading about Henry Ford. Conversely, it was expected that a greater proportion of participants would describe the photo as a view of the sun or moon obstructed by a rod after reading about space travel. Given our coding scheme, we expected that those who read about Henry Ford would receive, on average, higher scores than those who read about space travel. As expected, scores were higher after reading about Ford (mean = 0.85) than after reading about space travel (mean = 0.0) ($t_{56} = 4.58$, $p < 0.001$).

Because we made specific predictions regarding the influence of each prime, we applied planned comparisons on the proportion of expected percepts, excluding the data from those participants who gave vague responses.[(2)] As expected, 50% ($n = 10$) of those who read about Henry Ford reported seeing a sign. However, only 8% ($n = 2$) of participants who read the space story reported a sign ($\chi^2_1 = 10.49$, $p = 0.001$).

3 Study 1B

Study 1B conceptually replicated study 1A. In addition, this study addresses a possible concern of the preceding experiment that the biasing information was presented in a context that linked it directly to the ambiguous visual stimulus. That is, because of our instructions, participants were attempting to link the prime to the photos including the ambiguous figure. With the current experiment, we wanted to open participants' verbal descriptions to topics not necessarily constrained by the biasing information by eliminating the suggestion of a link between the prime- and object-identification tasks.

3.1 *Method*

Cornell University undergraduates ($n = 89$) learned that they would complete several unrelated, short computer tasks. Participants were seated individually in front of 17-inch eMac desktop computer. First, participants were randomly assigned to read one of two sets of paragraphs. Those randomly assigned to the music condition ($n = 44$) read discussions on the legality of the music-file-sharing service, Napster, and presented arguments both for its use or reasons it should be banned and users brought up on charges. Specifically, we discussed legal issues for artists and producers and concerns for distribution of royalties. We never mentioned specific artists (eg Kenny G) or groups of musicians (eg saxophonists).

Those randomly assigned to the porn condition ($n = 45$) read arguments concerning the legality of pornography and implications for basic human and constitutional rights. Although forms of the word *feminism* were used sparingly, we never mentioned specific people (eg Hillary), group of people (eg women), or gender (eg female). Thus, we provided no direct linguistic labels for the upcoming visual stimulus.

[(2)] Unexpectedly, vague responses coded as 0 did vary significantly between priming conditions ($\chi^2_1 = 12.29$, $p < 0.001$). In fact, all vague responses were from participants who read about Henry Ford. Although this unequal distribution of vague responses is of concern for this study, this problem is not present in the following studies.

Although reading times varied, participants completed their second, ostensibly unrelated task immediately after reading the paragraphs. During this task, participants initially read a brief instruction that stated they would see an image on the next screen. Then they saw the saxophone player/face ambiguous figure (figure 2; 4 inches tall $\times 1.8$ inches wide) for 1500 ms. After this, the computer instructed participants to report the image that appeared on their computer screen by describing the image on a response sheet. Following these tasks, participants completed the same questionnaire as described in the preceding study that probed for participants' understanding of the purpose of the study and the relationship between the tasks. No participant stated that we were interested in seeing how their interpretation of the figure would be influenced by what they read beforehand.

Figure 2. Ambiguous saxophone player/face figure.

3.2 *Results and discussion*

3.2.1 *Coding scheme.* We used the following method to code participants' responses. Given the bias to interpret the ambiguous figure as a face, responses from participants who reported seeing a face were scored as $+1$. Those reporting seeing a saxophone player received a score of -1. Finally, a large number of participants within this sample reported a vague description of the figure ($n = 20$) that did not clearly indicate whether they saw the saxophone player or the face (eg person). These responses were scored as 0. The proportion of vague responses did not vary systematically by priming condition ($\chi^2_1 = 0.20$, $p = 0.65$).

3.2.2 *Object identification.* We expected that the pornography prime would increase the likelihood that participants would report seeing a face compared to those primed with music. However, we expected that the music prime would increase the likelihood that participants would see the saxophone player as compared to those primed with pornography. Given our coding scheme, we expected that when the participants are primed with cues related to pornography, their mean scores should be higher than when primed with music. This is in fact what we found ($t_{87} = 2.40$, $p < 0.02$). Mean scores were higher when primed with pornography than when primed with music (means = 0.76, 0.43, respectively).

Because we made specific predictions regarding the influence of each prime on object identification, we applied planned comparison on the proportion of expected percepts excluding data from those participants who gave vague responses. Of those in the porn-prime conditions, 0% reported seeing a saxophone player but 23% ($n = 8$) of those in the Napster condition did ($\chi^2_1 = 10.31$, $p = 0.001$).

4 Study 2

Studies 1A and 1B demonstrated conceptual top–down constraints can bias the identification of visual information that contains more than one interpretation. Study 2 served as an extension by including a control condition that received no prime. In addition, study 2 allowed participants to self-generate primes. Self-generation increases the variability of the content of the conceptual prime but also provides an opportunity to test the contribution of both perceptual and conceptual information. By coding whether self-generated primes include information directly descriptive of one interpretation of the ambiguous figure (eg horse), we may test the relative contributions of direct cues and conceptual, indirect primes.

4.1 *Method*

Ninety Cornell undergraduates completed one of two types of self-generated priming packets. Participants were asked to assist in the creation of the text and illustrations of one of two children's books. Those randomly assigned to the farm prime condition ($n = 35$) chose a farm animal as the main character of a children's story, listed three peripheral animal characters in their packet, and wrote an introductory paragraph about their characters. Participants randomly assigned to the sea prime condition ($n = 29$) received the same prompts but created a tale surrounding a sea creature.

Immediately following this, in a second portion of the story-writing task, participants judged the appropriateness of a figure that was intended for inclusion in the children's book. On the page that followed the text creation prompts, participants read a set of instructions that asked them to turn the page, view the image on the following page for 1 to 2 s until they could identify the image, then turn to the third and final page. Participants were instructed to tap into their gut reactions, so they should view the drawing for only 1 to 2 s. Participants were told that at no point should they turn back to a previous page. For 1 to 2 s, participants viewed the horse/seal ambiguous figure (see figure 3) and then turned the page. On the final page, participants described the image and, to uphold the cover story, rated how appropriate the drawing would be for inclusion in their children's story. Additionally, participants completed a funneled probe for suspicion that asked (i) if anything was unusual about the image, (ii) if anything else appears on the page in addition to what they provided in their initial description, and (iii) if there was anything about the figure that made it difficult to identify.

A third group of participants ($n = 26$) did not receive a conceptual prime. They did not read a story nor were they asked to judge photographs for their relevance to a children's book. Instead, this control group read a set of instructions that asked them to turn the page, view an image on the following page for 1 to 2 s until they could identify the image, then turn to the third and final page. At no point should they turn back to a previous page. For 1 to 2 s, participants viewed the horse/seal ambiguous figure and described the image.

4.2 *Results and discussion*

These studies aimed to demonstrate the effects of top–down priming on object recognition as opposed to memory for previously viewed images. As a result, data from those participants who acknowledged that they had seen the figure before ($n = 3$) were removed. Additionally, data from those participants who could blatantly describe the

Figure 3. Ambiguous horse/seal figure.

purpose of the study and link the two tasks were removed ($n = 4$) as advised by Bargh and Chartrand (2000), because of concerns of reaction towards the prime. For those who are aware of the purpose of the prime, measures of the effects of implicit priming techniques are not valid, as contrast effects or experimenter demand effects may occur. This left data from 83 participants for analyses.

4.2.1 *Coding scheme.* Given the bias toward seeing this figure as a horse, participants who reported a horse received a score of +1. Those who saw it as a seal received a score of −1. Finally, responses that were too vague to be classified as either a horse or seal ($n = 16$) received a score of 0. The proportion of vague responses did not vary systematically among conditions ($\chi^2_2 = 0.35$, $p = 0.84$).

4.2.2 *Object identification.* We expected that the distribution of percepts would vary as a function of prime type. Specifically, we expected that a greater proportion of participants would report a seal after creating a sea animal story than after a farm animal story. Given our coding scheme, we expected those who wrote a story about farm animals would receive a higher score on average than those who wrote about sea animals. As expected, scores depended upon priming condition ($F_{2,80} = 3.38$, $p = 0.04$). In particular, scores were higher for those who wrote about farm animals (mean = 0.82) than for those who wrote about sea animals (mean = 0.39) ($t_{55} = 2.63$, $p = 0.01$). While scores for the control group fell in the middle of both of the story conditions (mean = 0.54) (farm and control: $t_{58} = 2.00$, $p = 0.05$; sea and control: $t_{47} = 0.67$, $p = 0.51$).

Because we made specific predictions regarding the influence of each prime, we applied planned comparisons on the proportion of expected percepts excluding the data from those participants who gave vague responses. As expected, interpretations depended upon what type of story participants wrote ($\chi^2_2 = 7.71$, $p = 0.02$). Specifically, 100% ($n = 28$) of those who wrote about farm animals reported seeing a horse. However, this bias was reduced to 74% ($n = 14$) after writing about sea animals. Finally, 85% of those in the control condition ($n = 17$) reported a horse.

4.2.3 *Direct versus incidental cues.* In addition, we expected that biased resolution would be a result of the activation of conceptual information and not be driven by mention of direct perceptual information. To test the contributions of direct cues and

conceptual set on resolution, we looked at the nature of the information contained within the story participants generated. We coded whether participants listed an animal that was directly descriptive of one of the possible interpretations of the figure. First, collapsed across both conditions, 56% ($n = 32$) of participants listed an animal that was one of the possible interpretations of the figure. Specifically, these participants listed a horse or donkey when asked to write about farm animals or listed a seal when asked to write about sea animals.

To test the alternative explanation that the effect of conceptual set priming is a result of the direct mention of a target animal, we included as a factor whether participants listed this specific animal in the priming phase. If it is the case that bias in object identification requires the activation of specific information or directly related perceptual cues, then inclusion of this independent variable should eliminate or at least reduce the effect of the priming manipulation. However, if conceptual cues bias interpretation without requiring the preemptory activation of a specific animal, then including this independent variable should significantly predict ambiguity resolution.

To test these competing alternatives, we ran a 2 (prime: farm, sea story) $\times$ 2 (did list, did not list target animal) ANOVA. As expected by the conceptual set priming explanation, scores representing reported interpretations of the figure depended on whether participants were randomly assigned to write about farm or sea animals ($F_{1,53} = 8.11$, $p = 0.006$). Direct mention of the target did not significantly influence scores ($F_{1,53} = 1.34$, $p = 0.25$). In contradiction to the alternative explanation that direct linguistic cues are required to bias ambiguity resolution, the interaction between prime type and listing the target animal did not reach a conventional level of significance ($F_{1,53} = 2.79$, $p = 0.10$). Listing a horse or donkey among the characters of a farm story did not bias interpretations of the figure. The average score for those who did not list a horse or donkey when writing about farm animals (mean = 0.75) did not significantly drop in comparison to the average score of those who listed a horse (mean = 0.85) as would be expected by the alternative explanation ($t_{32} = 0.61$, $p = 0.55$). In other words, participants who did not create a story involving a horse were just as likely to interpret the ambiguous stimulus as a horse as participants who did.

In addition, the average score for those who did not list a seal when writing about sea animals (mean = 0.53) did not significantly increase in comparison to scores from participants who listed a seal (mean = 0.00) ($t_{21} = 1.35$, $p = 0.19$), as would be expected by the alternative. Although the direction of the means within this prime type suggest a nonsignificant tendency for participants to interpret the ambiguous figure as a seal after listing a seal as a character during the conceptual priming phases as would be predicted by the direct cue explanation, we are hesitant to make conclusions about the power of conceptual cues given the unequal distribution and self-selected inclusion of participants within each of the 4 cells of this analysis, in addition to the asymmetrical distribution of percepts within the non-primed, control condition. That said, these data do not offer consistent support for the alternative explanation that conceptual set priming effects depend upon the activation of direct linguistic labels.

5 Study 3

Although the previous study argues that incidental conceptual sets influence object identification, it is not possible to eliminate the possibility that participants who did not write down the target animal when asked to list four animals did not consider, think about, or imagine the target animal without listing it. That is, direct linguistic labels may have been activated but not reported. Thus, in this study, we turn to an ambiguous figure whose interpretations lack direct linguistic labels that might be suggested by the conceptual prime.

Additionally, the preceding studies used both linguistic biasing information and linguistic descriptions as the dependent measure. To address the possibility that language and not perception mediates the influence of the incidental conceptual prime and biased object identification, study 3 moved to a dependent measure that was not a language-based description. In addition, we included a third priming condition to serve as a control condition to our two other conceptual priming conditions. Participants read 1 of 3 narratives describing the view as someone looks up a tall building, down a deep canyon, or straight out along the Midwestern Plains. Then participants saw a drawing of a Necker cube and indicated the orientation of the cube by clicking on a face of the cube that appeared closer to them.

We expected that the narrative describing the view as someone looking up a tall building would increase the likelihood that people saw the cube as if they were looking up at it. The narrative describing the view down a canyon was expected to increase the likelihood that participants would see the cube as if they were looking down at it. Finally, the Great Plains narrative was expected to produce relatively equi-biased perceptual experience in comparison to the other two directional priming conditions.

5.1 *Method*

Cornell University undergraduates ($n = 124$) were seated individually in well-lit cubicles in front of a 17-inch eMac desktop computer. Participants were randomly assigned to read one of three sets of paragraphs that described specific details about an environment. Borrowing a paragraph used by Spivey and Geng (2001), those in the upward-looking condition ($n = 32$) were asked to imagine that they "are standing across the street from a 40-storey apartment building, at the bottom of which is a doorman in blue. On the 10th floor, a woman hangs her laundry out the window. On the 29th floor, two kids sit on the fire escape smoking cigarettes. On the very top floor, two people scream." Again, borrowing a paragraph used by Spivey and Geng (2001), those in the downward-looking condition ($n = 32$) imagined standing at the top of a canyon where several people prepared to repel down the canyon wall. The first person was described as "descending 10 ft before she was brought back to the wall. She jumped again, fell 12 ft, and then jumped another 15 ft. And the last jump, of 8 ft, took her to the canyon floor." Finally, those assigned to the flat, or control, condition ($n = 60$) imagined standing in a field in the Midwestern Plains. Without obstruction, one can see the edge of the horizon. The horizon appeared as a sharp line across one's field of view. The first light from the morning sun was seen. The yellow light slowly got brighter and brighter.

Immediately after reading one of these three paragraphs, participants read instructions that indicated they would next see a drawing that included two blue lines. They should click on the blue line that appeared closest to them. What we showed them, though, was a Necker cube (4 inches $\times$ 3.75 inches). The cube's lines were black except for two horizontal blue lines. Of the lines that form the face of the downward-facing cube, we colored blue the top line. Of the lines that form the face of the upward-facing cube, we colored blue the bottom line. In other words, the highest blue line, if closest, corresponded to an interpretation of the Necker cube as pointing downward towards the participant. The second, lowest blue line corresponds to an interpretation of looking up at the cube. The cube stayed on participants' screen until they clicked on the blue line that appeared closest to them, thereby providing a perceptual judgment of the orientation of the three-dimensional cube. We expected that the upward prime would increase the likelihood that participants would click on the line of the cube that suggested they were looking up at the cube; the downward prime would increase the likelihood that participants would click on the line that suggested they were looking down at the cube; while those with the flat or control prime should be relatively

equi-biased in their perceptual experience in comparison to the other two directional priming conditions.

5.2 *Results and discussion*

5.2.1 *Object identification.* As expected, prime type influenced participants' perceptual experience of the Necker cube ($\chi^2_2 = 10.40$, $p = 0.006$). Specifically, 81.3% ($n = 26$) of those who received the downward prime clicked on the line of the cube that suggested they were looking down at the three-dimensional figure, while 18.8% ($n = 6$) clicked on the line that suggested they were looking up at the figure. However, 43.8% ($n = 14$) of those who received the upward prime clicked on the line that suggested they were looking down at the cube, while 56.3% ($n = 18$) clicked on the line that suggested they were looking up at the cube. Importantly, those in the control condition who received the flat prime fell in between. That is, 68.3% ($n = 41$) of those in the flat prime suggested they were looking down at the cube while 31.7% ($n = 19$) suggested they were looking up at it.

6 General discussion

Previous research on top–down constraints provided evidence for direct influences, be it perceptual or linguistic, over visual processing. This research extends previous investigations by suggesting the breadth of top–down influences is greater than originally demonstrated. Studies 1A and 1B provided evidence that indirect, conceptual information biases interpretation of an ambiguous figure. Study 2 addressed the alternative explanation. Rather than supporting the proposition that direct linguistic cues underlie conceptual set effects, the data suggested otherwise. Primes devoid of direct mention of possible resolutions of the ambiguous stimulus were no less effective at biasing perceptual resolution than primes that mention one of the possible interpretations. Top–down modulation does not require the activation of direct perceptual set. Study 3 addressed the possibility that language and not perception mediated the influences of conceptual primes on object identification.

6.1 *Limitations*

There are indeed a few points of contention that should be addressed. First, one may argue that the change in identification that we attribute to the activation of conceptual set may have been mediated by imagery (Kosslyn 2003). Engaging participants in stories or exposing them to lexical items indirectly related to figure interpretations may have activated mental images that pertained directly to one of the possible interpretations of the figure (a horse). Study 2 addressed this concern and argued that the change in identification was influenced just as strongly regardless of whether the participant thought of direct perceptual information. This result serves to support our argument that direct perceptual information is not necessary to systematically bias object identification. However, it is still possible that the thematic properties of the priming task in study 2 subtly activated direct perceptual information that participants did not report. As a result, study 3 used an ambiguous figure whose interpretations lacked linguistic labels that could have been suggested by the conceptual prime. In addition, future studies may employ online measures of lexical and visual processing in order to address the possibility that direct perceptual information might mediate the relationship between conceptual set and object identification.

As a second point of contention, some may argue that our participants had a relatively large amount of time to evaluate the object (between 1 and $\sim$2 s) with respect to the rapidity with which the visual system can pick up low-level cues. Although between 1 and 2 s can be arguably considered quite a long period for viewing the figure, funneled debriefing of participants suggested that within this time frame and

with the instruction to only glance at the figure until they could report what they saw, participants did not realise that more than one interpretation was possible.

Additionally, future work that tracks first saccades and later eye movements might speak to the mechanism that mediates conceptual set and identification as well as speaking to the stage of perceptual processing at which conceptual set impinges. As suggested earlier, we propose that conceptual set may direct attention to elements of the ambiguous figure that lead to a specific perceptual conclusion. Elements that are congruent with the conceptual prime might be processed prior to other elements or to a greater extent than those elements that are incongruent with the conceptual prime. Future studies that use eye-tracking methodologies would be able to test this form of a selective attention mechanism, and also a speeded classification of visual stimuli task (eg Palmeri and Blalock 2000). This paradigm, in collaboration with eye-tracking methodologies might suggest whether conceptual set influences early stages of visual processing or later stages of processing that might be called perceptual judgments. We predict that the speed with which participants would respond to a forced classification of an ambiguous figure and the first saccades observers make to focal elements of a figure would remain consonant with the content of the activated conceptual set.

Another important concern is whether conceptual set influences observers' bias or sensitivity in object identification. Although signal detection theory is often employed to address this issue, the paradigm that allows researchers to test the rates of hits and misses would introduce a confound we actively avoided. Namely, using a paradigm that requires multiple presentations of the same ambiguous stimulus makes it difficult to conclude whether conceptual set influences novel identification, or its influence is on memory for the label assigned to the previously seen object. However complicated, the issue of bias and sensitivity is an important one that might be addressed, again, with eye tracking. Systematic variation among different focal areas and differences in the time it takes to saccade to a component of the figure could suggest whether conceptual set influences bias or sensitivity within a single presentation of the ambiguous figure.

Despite these limitations, the experiments reveal the impact of incidental top–down cues on object identification. Even when perceivers are not directly attending to a stimulus array, or cued consciously and directly by perceptual information, the visual system is actively building anticipations that may influence bottom–up processing.

7 Summary

Certainly, research concerning object identification has a rich history and remains an important endeavour in the cognitive sciences. Models of object identification must certainly include bottom–up and top–down sources of bias. This paper aimed to outline a distinction within the top–down perspective that has gone largely underrepresented in the existing empirical literature. In particular, we emphasize the value of hybrid models that incorporate both bottom–up and top–down constraints on identification but that also consider the full range of each type of constraint. We argue that incidental conceptual sets constrain subsequent identification of ambiguous visual information without requiring the activation of direct perceptual cues. To achieve a comprehensive understanding of perceptual systems, it is necessary to include comprehensive search for both direct perceptual and incidental conceptual constraints.

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