Facilitatory and Inhibitory Effects of Implicit Spatial Cues on Visuospatial Attention

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Abstract

Previous work suggests that both concrete (e.g., hat, shoes) and abstract (e.g., god, devil) concepts with spatial associations engage attentional mechanisms, affecting subsequent target processing above or below fixation. Interestingly, both facilitatory and inhibitory effects have been reported to result from compatibility between target location and the meaning of the concept. To determine the conditions for obtaining these disparate effects, we varied the task (detection vs. discrimination), SOA, and concept type (abstract vs. concrete) across a series of experiments. Results suggest that the nature of the concepts underlies the different attentional effects. With abstract concepts, facilitation was observed across tasks and SOAs. With concrete concepts, inhibition was observed during the discrimination task and for short SOAs. Thus, the particular perceptual and metaphorical associations of a concept mediate their subsequent effects on visual target processing.
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1 Introduction

In what ways can one location in the visual field be selectively favored for faster or more elaborate processing? Although a sudden change in the periphery can reflexively draw our attentional resources to the location of change (Posner, 1980; Yantis & Jonides, 1984), there are several kinds of visual stimuli that, when processed at fixation, can also produce automatic biases of visuospatial attention toward a peripheral location. These include gaze cues (e.g., Friesen & Kingstone, 1998; Driver, Davis, Ricciardelli, Kidd, Maxwell, & Baron-Cohen, 1999), arrows (e.g., Hommel, Pratt, Colzato & Godijn, 2001; Tipples, 2002), and direction words (e.g., Hommel et al., 2001). More recently, it has been suggested that even words like "happy" or "hat", although more implicitly associated with location information, can bias visuospatial attention toward locations compatible with their meaning (e.g., Estes, Verges, & Barsalou, 2008; Meier & Robinson, 2004).

The automaticity of attentional shifts with many central stimuli has been supported when employing the attentional cuing paradigm (Posner, 1980; Posner & Cohen, 1984). A typical trial of an attentional cuing task - with central cues - begins with a fixation mark at the center of the display, which is then replaced by a cue stimulus that, though indicating a location, does not predict the location of the upcoming target. On cue-target compatible trials, then, the target appears at the location indicated by the cue, whereas on cue-target incompatible trials the target appears at a different location. Shifts of attention toward the cued locations are inferred when responses on compatible trials are faster or more accurate than responses on incompatible trials (e.g., Friesen & Kingstone, 1998; Hommel et al., 2001; Pratt, Radulescu, Guo, & Abrams, 2010; Ristic & Kingstone, 2006; Stevens, West, Al-Aidroos, Weger, & Pratt, 2008).

At present, the central stimuli that have been used as cues for visuospatial attention can be grouped into two broad categories. The first category consists of all spatial stimuli that can explicitly point to a location in space. These stimuli are referred to as spatial indices (Clark, 1996; Logan, 1995) and include arrows, direction words, and gaze direction. It has been argued that the spatial meaning of each of these indices is over-learned and, therefore, can elicit an orienting response automatically (Hommel et al., 2001; Pratt et al., 2010; Ristic & Kingstone, 2006). The second category of stimuli, however, do not explicitly point to a location and yet have a strong association with specific locations. Notable examples of this kind of attentional cues are numbers (Fischer et al., 2003), words referencing past or future (Weger & Pratt, 2008),
words referring to objects with a typical perceived location (e.g., "hat", "shoes", "attic", "basement"; Estes et al., 2008), and words referring to abstract concepts that are metaphorically associated with a location in space (e.g., "powerful", "God", "Devil", "happy", "sad"; Chasteen et al., 2010; Meier & Robinson, 2004). The focus of the present study is the second category of spatial cues, hereafter referred to as implicit cues.

It is important to note that although explicit and implicit spatial cues have been employed in experiments that are virtually identical (i.e., cue presented at fixation followed by a peripheral target either at the compatible or incompatible location), the examination of the two types of cues have been motivated on different theoretical grounds. Whereas studies on explicit cues address the sensitivity of the attentional mechanisms to spatial signs and the automaticity of the biases generated by those signs, studies of implicit cues primarily address the nature of conceptual representation in the brain. For instance, the observation that small and large numbers can bias attention toward the left and right of side of the visual field, respectively, has been taken as evidence for the proposal that the representation of numbers has an inherent spatial component (Fischer et al., 2003; Dodd et al., 2008). Similarly, biases of visuospatial attention using word cues referring to abstract concepts related to the past or future (e.g., Weger & Pratt, 2008), valence (e.g., "happy", "sad"; Meier & Robinson, 2004), divinity (e.g., "God", "Devil"; Chasteen et al., 2010), or power (e.g., "master", "servant"; Schubert, 2005) have been taken as evidence that representations of these concepts rely on the neural mechanisms responsible for processing space (Quadflieg et al., 2011, Hubbart et al., Meier & Robinson, 2005).

Thus, it has been proposed that the effects of implicit cues on attention suggest the fundamental dependence of higher-level conceptual representation on basic sensorimotor and perceptual experiences with space, time, and other physical properties (Gallese & Lakoff, 2005; Lakoff, 2008; Lakoff & Johnson, 1999). According to this account, concept representation does not become independent from the neural mechanisms underlying perception and action that allow acquisition of the concepts in the first place (Barsalou, 1999; 2003; 2008; Lakoff, 2008). Subsequent activation of the concept, therefore, causes the activation of the perceptual information stored during direct experiences with the concept's referents (e.g., representing the concept of 'grasp' depends on the sensorimotor regions of the brain that are active during the act of grasping). This process is termed simulation and is a central element to the theory of perceptual symbol systems (PSS), introduced by Barsalou (1999). According to PSS theory, what enables us to think and reason in abstract terms is the patterns of neural re-activation (i.e.,
simulation) that correspond to experiencing physical properties of the world. The perceptual mechanisms are thought to support concept representation even when the concepts do not have direct perceptual and sensorimotor correlates (e.g., 'past', 'future', 'happy', 'sad', 'divine', 'evil'), through a process of metaphorical mapping, which enables the brain to acquire and reason about abstract concepts in terms of physical and spatial properties (e.g., 'happy' is bright and upward, whereas 'sad' is dim and downward; Lakoff & Johnson, 1999; Meier & Robinson, 2005; Meier, Robinson, & Clore, 2004).

Several lines of study have tested and provided support for the simulation view of concepts by specifically examining whether spatial connotations of a concept would influence the visual-perceptual processes (Estes et al., 2008; Šetić & Domijan, 2007; Zwaan & Yaxeley, 2003; Chasteen et al., 2010; Meier & Robinson, 2004; 2005; Shubert, 2005). This is where studies using implicit spatial cues become relevant. One surprising fact, however, is that both facilitation (Chasteen et al., 2010; Meier & Robinson, 2004) and inhibition (Estes et al., 2008) of visual processing - in the location compatible with the cue's meaning - has been taken as support for this view. In particular, Estes' et al. (2008) used words referring to concrete concepts associated with typical locations (e.g., "hat", "boots"), as implicit cues in a visual discrimination task. In their third experiment, after viewing a single word, a letter target ('X' or 'O') was presented above or below fixation. The authors found slower and less accurate processing on cue-target compatible trials (e.g., "hat" and target above), relative to incompatible trials (see also Bergen, 2005; Richardson, Spivey, Barsalou & McRae, 2003). Target inhibition, the authors suggested, resulted from the spatially-specific perceptual simulation of the cue's referent that interfered with the concurrent target identification at the compatible location.

By contrast, using a similar design, Chasteen et al. (2010) presented their participants with abstract concepts of divine and evil (e.g., "God", "Satan") in a target detection task. In their experiments, after viewing each word, a single luminance target appeared in the periphery and participants were instructed to press the spacebar as soon as they saw the target unless the cue did not refer to a religious concept. Unlike Estes et al., the authors found faster responses on cue-target compatible trials (e.g., “God” and target above), relative to incompatible trials. The authors interpreted that facilitation resulted from attentional orienting toward the location compatible with the cue's referent because of the over-learned metaphorical mapping between the concepts and space (see also, Meier, Hauser, Robinson, Friesen, & Schjeldahl, 2007).
Both sets of findings, and their subsequent interpretations, have invoked the view that concept representation relies on lower level neuro-cognitive mechanisms, including the mechanisms underlying visuospatial orienting. On the one hand, it has been argued that engaging the visuospatial mechanisms, via activating of concept representation, renders them unavailable for other concurrent visual tasks (e.g., Bergen, 2005; Estes et al., 2008). On the other hand, however, it has also been argued that engaging the visuospatial mechanisms primes and facilitates concurrent visual tasks requiring the same spatial orienting (e.g., Chasteen et al., 2010; Meier & Robinson, 2004). Both interpretations seem sensible and consistent with the perceptual, simulation-based views of concepts. Consequently, the disparate findings reported by Estes et al. (2008) and Chasteen et al. (2010) might be attributable to any number of differences in their task characteristics (see Table 1). These include the difference between the concepts (e.g., concrete vs. abstract), cue-target stimulus onset asynchrony (SOA; short vs. long), visual task (discrimination vs. detection), and cue treatment (passive viewing vs. categorization), and possible interactions between these factors.

The type of concepts used in the studies by Estes et al. (2008) and Chasteen et al. (2010) might have been the reason for the opposite patterns of findings. It is possible that the representations of concrete concepts used by Estes et al. have more perceptual details (Wiemer-Hastings & Xu, 2005; Wang, Conder, Blitzer, & Shinkareva, 2010) and therefore impose a stronger perceptual bias (Bundesen, 1990) during target processing relative to the abstract concepts used by Chasteen et al. (2010).

Besides the possible effects of concept type, the temporal proximity (i.e., short cue-target SOA) between the activation of concept representation and processing of the visual target may be responsible for finding interference with target processing. That is, if the visual task follows the processing of the concept after enough delay, then the residual effect of concept processing may facilitate target processing in the compatible location (Bergen, 2007). This seems consistent with the reports: Estes et al. (2008) used SOAs between 150 and 350 ms, obtaining interference (also see Bergen, 2005; SOA = 200 ms), while Chasteen et al. (2010) used SOAs between 800 to 1200 ms, obtaining facilitation. In studies wherein presentation of the visual target occurs only after a separate response (e.g., verbal categorization) to the cue, we also find facilitatory effects of cue-target compatibility (Meier & Robinson, 2004), consistent with a critical role of cue-target temporal proximity.
Another important difference between the two studies is the treatment of visual targets. Whereas Chasteen et al. asked participants to make a keypress response as soon as they detected the luminance target, Estes et al. required participants to discriminate between two possible target identities (‘X’ vs. ‘O’) necessitating higher visual processing depth before making a response. Target identification relies on processes that are psychophysically distinct from target detection (i.e., having different sensitivities and time-course; de la Rosa, Choudhery, & Chatziastros, 2011; Johnston, McCann, & Remington, 1995; Remington & Folk, 2001). It is, therefore, possible that the overlap between concept representation and target location would benefit detection only, while interfering with more elaborate visual perception that is necessary for target discrimination.

Lastly, the difference in the findings may be because of the different ways in which the cues were treated. Whereas Estes et al. asked participants to simply view the cues and then respond to the targets, Chasteen et al. made responses contingent upon cue category (i.e., respond only when the cue refers to a religious concept). Such a link between the cue and the response may have caused the cue and the target to be integrated into a single event, subsequently causing cue-target compatibility to receive facilitation compared to incompatible pairings. Accordingly, perhaps Estes et al. observed inhibition because they did not make such a link between the cue and responding to the targets, leaving the cue as a truly irrelevant stimulus. Preserving the functional separation between simultaneous mental processes has been proposed as a necessary condition for interference (e.g., Gozli & Pratt, in press; Musseler, 1999; Zwickel & Prinz, in press).

In the following experiments, we varied all potentially relevant task characteristics across the two representative tasks (Table 1) in order to pinpoint the specific conditions wherein

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facilitation or inhibition would be observed. We began by replicating the findings of Chasteen et al. (2010) and examining how those findings would change when using a visual discrimination task (Experiment 1) and short SOAs (Experiment 2). Next, we replicated the findings of Estes et al. (2008) and examined how those findings would change when using a visual detection task (Experiment 3) and long SOAs (Experiment 4). Finally, we tested whether the findings of Estes et al. would change when response performance becomes contingent upon cue category, similar to the task used by Chasteen et al. (Experiment 5).

2 Experiment 1

In this experiment we asked whether the facilitated processing of cue-target compatible trials reported by Chasteen et al. would be modulated by different visual tasks (detection vs. discrimination). Like Chasteen et al., we used implicit cues referring to concepts of divine and evil, which were followed by targets along the vertical axis. In addition to the detection task used in the original study, this experiment also included a block in which participants performed a discrimination task. If visual task alone can predict whether cue-target compatibility leads to facilitation or inhibition, then we should observe facilitation in the detection task and inhibition in the discrimination task.

2.1 Method

Participants

Twenty-seven undergraduate students at the University of Toronto participated in the experiment in exchange for course credit. All participants were right-handed and had normal or corrected-to-normal vision. They were all naïve to the purpose of the study.

Apparatus and procedure

The experiment was run in Matlab (MathWorks, Natick, MA) using the Psychophysics toolbox (Brainard, 1997; Pelli, 1997, version 3.0.8). Stimuli were presented on a 14” x 10” CRT monitor set at 1280 x 720 pixels resolution and a refresh rate of 85 Hz. The viewing distance from the monitor was fixed at 44 cm, using a chin/head rest. The participants' eyes were monitored in order to ensure compliance with the instruction.

Cue and target stimuli were presented in white against a clear, black background. Cue stimuli consisted of three different word categories; words associated with up ('GOD', 'LORD',...
and ‘CREATOR’), words associated with down (‘DEVIL’, ‘SATAN’, and ‘LUCIFER’) and neutral words (‘BALL’, ‘HOUSE’, ‘DOOR’, ‘FLOWER’, ‘PENCIL’, and ‘BANANA’). Participants were instructed to respond to targets whenever the centrally presented word referred to a religious concept and withhold response otherwise. Thus, religious concepts associated with up or down signified test trials, in which participants were required to respond to the targets, while neutral words signified catch trials, in which participants were required to withhold response. The cues were presented at the center of the screen in a 14-point Arial font. In the detection task, the target stimulus was a white square (.5° x .5°) presented 8° above and below the central fixation point. In the discrimination task, target stimuli were letters 'X' and 'O', in 14-point Arial font and subtending .4° x .6°, presented 8° above and below the central fixation point.

Figure1. Sequence of events in a sample (compatible) trial of the detection task. Cue-target stimulus onset asynchrony (SOA) were categorically varied across experiments (i.e., long SOAs in Experiments 1 and 3; short SOAs in Experiments 2 and 4) and then randomly chosen from an interval (e.g., 200-400 for short SOAs) for every trial. In the discrimination task, instead of the luminance target, a letter (‘X’ or ‘O’) was presented.

Each trial began with a fixation cross (‘+’) presented at the center of the screen, subtending .5° x .5°. Participants were instructed to maintain their gaze on this marker and wait for the cue stimulus. After 1000 ms, the fixation cross was replaced by the cue. After a long (i.e., a randomly chosen duration between 800 to 1200 ms) SOA, the peripheral target appeared above or below the word and remained present until a response was made or 2000 ms elapses.

During both the detection and the discrimination tasks, participants were instructed to respond to the targets only when the cue referred to a religious concept. Thus, response performance was contingent upon cue category. On the detection block, participants were instructed to respond to the onset of the target as quickly as possible by pressing the spacebar.
On the discrimination task, participants were instructed to identify the target as quickly as possible by the “z” key (for ‘O’) or the “/” key (for ‘X’). Participants received error feedback whenever their response times were shorter than 100 ms ("TOO QUICK!") or longer than 2000 ms ("TOO SLOW!") on test trials, whenever they responded with a wrong key on a test trial, during the discrimination task ("MISTAKE!"), and whenever they made a response on a catch trial ("MISTAKE!").

**Design**

Each participant performed in one block of target detection and one block of target discrimination task, the order of which was counterbalanced across participants. Each block consisted of 20 practice trials and 216 experimental trials (144 test trials and 72 catch trials). Cue category (i.e., up, down, neutral), cue identity, target location, and target identity were randomized such that each combination was equally likely on any given trial in a block. For data analysis, test trials were divided to cue-target compatible and incompatible groups.

### 2.2 Results and Discussion

One participant was replaced due to having a high rate of errors (26%) on catch trials indicative of a low degree of cue processing. For analysis of response times (RTs), catch trials and error trials (i.e., RT < 100 ms or RT > 2000 ms; wrong keypress during the discrimination task) and responses 2.5 SDs slower or faster than the total mean were excluded. The rest of the data were submitted to a 2 x 2 repeated measures analysis of variance (ANOVA) with task type (detection vs. discrimination) and trial type (compatible vs. incompatible) as independent measures (see Figure 2). This ANOVA revealed a main effect of task type \[ F(1,26) = 155, \text{MSE} = 3526, p < .001, \eta_p^2 = .857 \] and a main effect of trial type \[ F(1,26) = 8.89, \text{MSE} = 214, p < .01, \eta_p^2 = .255 \], but no interaction between the two factors \[ F(1,26) = 1.13, \text{MSE} = 198, p > .05, \eta_p^2 = .042 \]. Responses on the detection task (M ± SE = 359 ± 14 ms) were faster than the discrimination task (502 ± 15 ms), and responses on compatible trials (426 ± 13 ms) were faster than incompatible trials (435 ± 14 ms).

Error data were submitted to a similar 2 x 2 ANOVA with task type and trial type as independent factors. This ANOVA revealed a main effect of task type \[ F(1,26) = 9.50, \text{MSE} = 001, p < .001, \eta_p^2 = .268 \], which is trivial since choosing a wrong keypress is only possible during the discrimination task (error rate = 4.5%) and the only errors on the detection task were
due to anticipations and slow responses (2.7%). Importantly, however, no main effect of trial type was revealed [F < 1]. Nor was there an interaction between the two factors [F < 1]. On average, the error rates on catch trials were low on both tasks (1.7%), indicating that participants were processing the cues and withholding response after neutral cues.

Figure 2. Response time data from Experiment 1 (abstract concepts; long SOAs) graphed as a function of task type and cue-target compatibility. Error bars indicate the 95% within-subjects confidence intervals (Cousineau, 2005).

Findings from the detection task were a direct replication of the experiment reported by Chasteen et al. (2010). In addition, finding the same pattern of results in the discrimination task ruled out the possibility that the facilitated responses on cue-target compatible trials are dependent on not having to visually identify targets. Rather, it seems the locations compatible with the concept meaning were selectively favored in both tasks, resulting in a general facilitation in visual target processing. Therefore, so far, it seems that the major difference between the two studies (Table 1) was not the different types of responses to the visual targets. The timing of Experiment 1, however, was matched with the experiments reported by Chasteen et al. (2010). It is possible that long SOAs (800 - 1200 ms) are responsible for changing the effect of compatibility from inhibition to facilitation (Bergen, 2007). This issue is addressed in the next experiment.
3 Experiment 2

After ruling out the possibility that the type of visual task (detection vs. discrimination) determines whether facilitation or inhibition is observed as a result of cue-target compatibility with implicit spatial cues, in this experiment we asked whether reducing the delay between the onset of the cue and onset of the target would switch the facilitation effect to inhibition. Similar to Experiment 1, we used cues referring to concepts of divine and evil, which were followed by targets along the vertical axis in a detection and a discrimination task. Instead of long SOAs (i.e., 800 – 1200 ms), however, we used short SOAs (200 – 400 ms) following Estes et al. (2008). If SOA alone can predict whether cue-target compatibility leads to facilitation or inhibition, then we should observe inhibition in both tasks. If, however, the combination of short SOA and target discrimination are necessary for observing inhibition, then we should expect to see inhibition only in the discrimination task. Lastly, if SOA is not a critical factor for obtaining facilitation with this particular set of abstract concepts, then we should see the same pattern of facilitation observed in Experiment 1.

3.1 Method

Participants

Twenty-two undergraduate students at the University of Toronto participated in the experiment in exchange for course credit. All participants were right-handed and had normal or corrected-to-normal vision. They were all naïve to the purpose of the study.

Apparatus and procedure

The apparatus, stimuli, and procedure were exactly the same as the previous experiment, except for the delay between cue and target onsets that was randomly chosen for each trial from the interval between 200 and 400 ms.

Design

Similar to Experiment 1, each participant performed one block of target detection and one block of target discrimination, in counterbalanced orders. Each block consisted of 20 practice trials and 216 experimental trials (144 test trials and 72 catch trials). Cue category (i.e., up, down, neutral), cue identity, target location, and target identity were randomized such that each combination was equally likely on any given trial in a block. Test trials were divided into cue-target compatible and incompatible groups.
3.2 Results and Discussion

One participant had to be replaced due to a high error rate (22%) on catch trials, indicative of a low level of cue processing. RT data were trimmed in the same manner as the previous experiment and were submitted to a 2 x 2 repeated measures ANOVA with task type (detection vs. discrimination) and trial type (compatible vs. incompatible) as independent variables (see Figure 3). The ANOVA revealed a main effect of task type \[F(1,21) = 300, \text{MSE} = 2312, p < .001, \eta_p^2 = .935\] and a main effect of trial type \[F(1,21) = 7.10, \text{MSE} = 180, p < .05, \eta_p^2 = .252\] but no interaction between the two factors \[F(1,21) = 2.45, \text{MSE} = 70, p > .05, \eta_p^2 = .104\]. Responses on the detection (M ± SE = 328 ± 12 ms) task were faster than the discrimination task (505 ± 9 ms). Most importantly, responses on cue-target compatible (413 ± 9 ms) trials were faster than on incompatible trials (420 ± 10 ms).

Error data were also submitted to a similar 2 x 2 repeated measures ANOVA, which revealed no main effect or interaction \[Fs < 1\], suggesting that the RT findings did not result from a speed-accuracy tradeoff. On average, error rates were very low on catch trials (1% across both experiments), as well as on detection (2%) and discrimination (3%) test trials.

![Figure 3. Response time data from Experiment 2 (abstract concepts; short SOAs) graphed as a function of task type and cue-target compatibility. Error bars indicate within-subjects confidence intervals (Cousineau, 2005).](image)
These findings suggest that reducing the temporal delay between the cue and the target is also not what produces inhibition in implicit spatial cuing tasks. That is, it seems like at least with the cues used by Chasteen et al. (2010), inhibited target processing at cue-compatible locations cannot be observed in either type of task or SOA, constraining the possibilities even further for what predicts the direction of the effect. The most important remaining candidate that could be the source of the difference is the set of cues used in the two studies of Chasteen et al. (2010) and Estes et al. (2008). It remains possible that the concepts to which the cues refer involve different kinds of representation. It has been previously suggested that concrete concepts are associated with richer perceptual properties, whereas abstract concepts are associated with affective and introspective states (Kousta et al., 2011; Wang et al., 2010; Wiemer-Hastings & Xu, 2005; see also Barsalou 1999; 2008). It seems plausible, therefore, that the perceptual properties associated with concrete concepts are responsible for inhibited target processing at cue-compatible locations. Of course, this inhibition effect might only occur when target discrimination is required on trials with short cue-target SOAs (the exact setting used in the original report of Estes et al., 2008). Thus, to examine the conditions in which inhibition can be observed we attempted to replicate and extend the findings reported by Estes et al. to both tasks and SOAs in the next two experiments.

4 Experiment 3

After examining the representative task that resulted in facilitation of cue-compatible targets (Chasteen et al., 2010), in this experiment we moved on to examine the task that has resulted in inhibition of cue-compatible targets (Estes et al., 2008). Specifically, we tested whether the inhibited target processing found by Estes et al. is dependent on visual task, concept type, or both. If the relatively elaborate visual processing demanded by the discrimination task is necessary for observing the inhibition pattern, then inhibition will not be observed in a detection task. If the visual task alone is the critical factor for obtaining inhibition, then using target detection may even lead to the facilitation effect observed in the previous experiments. If, on the other hand, concept type (i.e., concrete concepts can lead to inhibition; abstract concept can lead to facilitation) and visual task both have a role in obtaining inhibition, then we expect to see inhibition in the discrimination task and no effect in the detection task.
We used the design of the third experiment reported by Estes et al., in which each target is preceded only by a single word cue referring to an object with a spatial connotation along the vertical axis. It is worth mentioning that in their first two experiments, the authors presented a context word (e.g., "cowboy") before each cue (e.g., "hat") to facilitate imagery further. Nevertheless, in their third experiment, they demonstrated that the context words were not necessary for the emergence of the inhibition effects.

4.1 Method

Participants

Twenty-six undergraduate students at the University of Toronto participated in the experiment in exchange for course credit. All participants were right-handed and had normal or corrected-to-normal vision. They were all naïve to the purpose of the study.

Apparatus and procedure

The apparatus, stimuli, and procedure were similar to the previous experiments, except when noted otherwise. We used the original word stimuli used by Estes et al. (2006). In their first experiment, the authors presented one of thirty context words (bear, bedroom, bicycle, house, bottle, broom, car, church, clock, coconut, corn, cowboy, desk, pencil, hand, cabin, flower, horse, hotel, home, table, mushroom, key, rain, truck, shower, street, tennis, football, trouser) on each trial, which was followed by a related second word that was either associated with up (snout, curtains, seat*, eye, cap, handle*, windows, steeple, tower, tree, stalk*, hat lamp, collar, ear, lamp, petal*, mane, roof, attic, peak, cap, surface, cloud, laces, spout, light, cloth, leaves, buckle*), or associated with down (claw, carpet, tire, talon, coaster, bristles*, wheels, pew, radio*, milk*, seed, boot, drawer, paw, foot, rug, stem, hooves, lobby*, cellar, base, stalk*, floor, puddle, soles, drain, corner, leg, roots, hem). Since in the present experiments we use single-word cues, we used the context words in filler trials to reduce the chance of participants

*Without their preceding context words (Estes et al., Experiments 1 & 2), five of the words in each of the critical group could no longer be associated with their designated category. Thus, we treated these words as fillers.
guessing the aim of the experiment. We did not include filler words in the analyses. Importantly, like the task used by Estes et al., participants always responded to the targets (without having to make a decision regarding the cue). The obvious disadvantage of this is not being able to examine whether participants processed the cues. Nonetheless, this was an important task characteristic in the original study and was, therefore, preserved. Furthermore, similar to Estes et al. (2008) we used short cue-target SOAs (200 – 400 ms).

This experiment differed from Estes et al. (2008; Experiment 3) in two respects. First, Estes et al. did not use filler/control words, whereas we did. Second, they presented the target after the cue offsets, whereas here the cue remained on the display until the trial ended. This was similar to Chasteen et al. (2010) and we did not expect this to have a major role in the nature of the effects. After all, the interaction between linguistic and spatial processes have been observed repeatedly in paradigms that display words until a response is performed, suggesting that activation of perceptual processes do not depend on the disappearance of the words (e.g., Pecher et al., 2010; Šetić & Domijan, 2007; Zwaan & Yaxley, 2003).

**Design**

Similar to the previous experiments, each participant performed one block of target detection and one block of target discrimination, in counterbalanced orders. Each block consisted of 20 practice trials and 180 experimental trials (100 test trials and 80 filler trials). Cue category (i.e., up, down, filler), cue identity, target location, and target identity were randomized and each combination was equally likely on any given trial. Test trials were coded as cue-target compatible and incompatible groups.

**4.2 Results and Discussion**

Response time data from all the correct trials were trimmed (in the same manner as Experiments 1 & 2) and were submitted to a 2 x 2 repeated measures ANOVA with task type (detection vs. discrimination) and trial type (compatible vs. incompatible) as independent factors (see Figure 4). This analysis revealed a significant effect of task type \(F(1,25) = 71.5, \text{MSE} = 2935, p < .001, \eta_p^2 = .741\), no significant main effect of trial type \(F(1,25) = 2.34, \text{MSE} = 143, p > .1, \eta_p^2 = .085\), and a significant two-way interaction \(F(1,25) = 5.76, \text{MSE} = 119, p < .05, \eta_p^2 = .187\).

Examining each task separately showed no effect of trial type in the detection task \(t(25) < 1\), with mean RTs being equal for compatible \((M \pm SE = 378 \pm 10 \text{ ms})\) and incompatible trials \((379\)
± 10 ms). On the other hand, for the discrimination task, there was an significant effect of trial type \[ t(26) = 2.57, \text{SE} = 3.40, p < .05 \]. Consistent with the previous reports of inhibition, we found slower responses on compatible trials (473 ± 10 ms) compared to incompatible trials (464 ± 10 ms) on the discrimination task.

Error data were also submitted to a similar 2 x 2 ANOVA, which only revealed a main effect of task \[ F(1,25) = 11.4, \text{MSE} = .001, p < .01, \eta^2_p = .314 \] and no other main effect or \[ Fs < 1 \] interaction. Examining the two tasks separately did not reveal a main effect of trial type on error rates \[ ts < 1 \], suggesting that the RT findings were not a product of a speed-accuracy tradeoff.

Figure 4. Response time data from Experiment 3 (concrete concepts; short SOAs) graphed as a function of task type and cue-target compatibility. Error bars indicate within-subjects confidence intervals (Cousineau, 2005).

The results of this experiment suggest that inhibition of target processing on compatible trials depends equally on concept types and how visual targets are treated. These findings are consistent with the interpretation provided by Estes et al. and others findings that suggest implicit spatial meaning in language can interfere with concurrent visuospatial processes (e.g., Bergen, 2005; Richardson et al., 2003). It is also consistent with the lack of a similar effect when using metaphorical spatial language (Bergen, 2005) or when the effect is completely reversed when using abstract concepts related to affect or religion. Could there be a difference in the time-course of the two effects observed with the two concept types, as well? In our first two experiments, we saw that the effect of religious concepts could be observed in both short and
long SOAs. Next, we address whether a similar preservation through time holds for the inhibitory effect of concrete concepts.

5 Experiment 4

To confirm the important role of concept type (i.e., concrete concepts lead to inhibition of cue-compatible targets), it needs to be shown that if the short SOAs used by Estes et al. are replaced by longer SOAs (similar to Chasteen et al., 2010), there will not be facilitation to cue-compatible targets. Hence, the previous experiment was repeated using long SOAs (800 – 1200 ms) in order to test the dependence of the inhibition effect on cue-target delay. With long SOAs, the perceptual activation may subside, making it possible to observe the residual spatial bias in reaction time data (see Bergen, 2007). If, however, the concept types used by Estes et al. cannot cause the same facilitation at the compatible target location observed in Experiments 1 and 2, then we should not see any cuing effect with long SOAs.

5.1 Method

Participants

Twenty-seven undergraduate students at the University of Toronto participated in the experiment in exchange for course credit. All participants were right-handed and had normal or corrected-to-normal vision. They were all naïve to the purpose of the study.

Apparatus, procedure, and design

Apparatus, stimuli, and procedure were exactly the same as Experiment 3, except for cue-target SOA. In every trial the target appeared with a delay randomly chosen from the interval between 800 and 1200 ms following cue onset.

Design

Similar to the previous experiment, each participant performed one block of target detection and one block of target discrimination, in counterbalanced orders. Each block consisted of 20 practice trials and 180 experimental trials (100 test trials and 80 filler trials). The number of trials resulted from following Estes et al.’s original design wherein each word was presented twice, paired with both target locations. Cue category (i.e., up, down, filler), cue identity, target location, and target identity were randomized and each combination was equally likely on any given trial. Test trials were coded as cue-target compatible and incompatible.
5.2 Results and Discussion

Response time data from all the correct trials were trimmed (in the same manner as previous experiments) and were submitted to a 2 x 2 repeated measures ANOVA with task type (detection vs. discrimination) and trial type (compatible vs. incompatible) as independent factors (see Figure 5). This ANOVA only revealed a main effect of task type \([F(1,26) = 273, \text{MSE} = 1198, p < .001, \eta_p^2 = .913]\). Neither a main effect of trial type nor a two-way interaction was found \([Fs < 1]\). For both tasks, responses were similar across the compatible (337 ± 8 ms and 449 ± 10 ms, respectively for detection and discrimination) and incompatible trials (339 ± 9 and 447 ± 9). Analysis of error data revealed the same pattern, with a main effect of task \([F(1,26) = 21, \text{MSE} = .001, p < .001, \eta_p^2 = .452]\), no main effect of trial type \([F(1,26) = 1.64, \text{MSE} = .001, p > .1, \eta_p^2 = .059]\), and no two-way interaction \([F < 1]\). Error rates were similar across both compatible (2% and 5.4%, respectively for detection and discrimination) and incompatible trials (1.3% and 4.9%).

![Figure 5](image.png)

*Figure 5.* Response time data from Experiment 4 (concrete concepts; long SOAs) graphed as a function of task type and cue-target compatibility. Error bars indicate within-subjects confidence intervals (Cousineau, 2005).

These results, together with those of Experiment 2, show that matching the SOAs across experiments does not lead to matching effects. Instead, the inhibition effect observed with the concrete concepts disappeared when the target is presented after enough delay following cue onset. Consequently, no difference between compatible and incompatible trials was observed. This, could be due to two reasons. First, with enough time the separate effects of spatial orienting
(causing facilitation) and perceptual simulation (causing inhibition) might balance out, causing the net null effect. Second, it may be that there was no spatial orienting effect. These two possibilities will be discussed further in the general discussion section, but it should be noted that this task alone cannot favor either of them. What we can suggest, nonetheless, is that the difference between the effects observed with the two types of concepts points to the distinction in the nature of how they are represented, in particular concerning the involvement of visuospatial mechanisms.

6 Experiment 5

To confirm the conclusion that concept type determines the direction of the effect observed as a consequence of cue-target compatibility, the role of one final factor needed to be examined. As indicated in Table 1, in the study of Estes et al. (2008), the cues were not evaluated in any way and were simply viewed prior to performing target discrimination. Moreover, a relatively large number of words (sixty) were used as implicit cues. We adhered to both of these characteristics when replicating and extending that study (Experiments 3 & 4). By contrast, Chasteen et al. (2010) instructed participants to only respond to visual targets when the word belonged to the category of religious concepts. Moreover, a relatively small number of words (six) were used as cues. In this final experiment, we asked whether the inhibition observed by Estes et al. could still be observed when participants are asked to categorically evaluate the cue, using a small (six) number of cues. It has been suggested that drawing a functional link between two stimuli (e.g., cue and target) may prevent the processes associated with the two stimuli from interfering with each other (e.g., Gozli & Pratt, in press; Musseler, 1999; Zwickel & Prinz, in press). Although never previously highlighted as a possible factor in predicting facilitation or inhibition, categorical evaluation of the cues has been used in previous studies of implicit spatial cuing. Šetić & Domijan (2007) observed facilitation in categorizing objects or animals when the words referring to these concepts were presented in compatible locations (e.g., faster response to “eagle” when presented above). Pecher et al. (2010) observed a somewhat similar effect when the entire category, based on which participants responded (e.g., things in the sky, or things in the sea), facilitated processing all words in its corresponding location. Although these studies suggest that the word itself would benefit from being positioned at the compatible location, it is
unclear whether this benefit should be observed for a separate visual stimulus that is functionally linked to the word via a categorical judgment.

In this experiment, we used a discrimination task that, based on the previous experiments, seems to be the necessary condition for observing inhibition. Moreover, to replicate the role of temporal delay, we used both short and long SOAs varying within the experiment. If cue treatment can alone determine whether inhibition or facilitation occurs with cue-target compatibility, then we should observe facilitation in the present experiment, because categorical judgment of the cues were always performed by subjects in previous experiments that found facilitation (Experiment 1 and 2; Chasteen et al., 2010). If, on the other hand, cue treatment does not play a role in the nature of the effect, then we should observe a disadvantage for cue-target compatible trials, similar to Experiment 3.

6.1 Method

Participants

Twenty-four undergraduate students at the University of Toronto participated in the experiment in exchange for course credit. All participants were right-handed and had normal or corrected-to-normal vision. They were all naïve to the purpose of the study.

Apparatus and procedure

Cue stimuli in this experiment consisted of three different word categories; words associated with up (‘ROOF’, ‘ATTIC’, and ‘STEEPLE’), words associated with down (‘BOOT’, ‘HOOVES’, and ‘FLOOR’) and neutral words (‘ART’, ‘JUSTICE’, ‘BEAUTY’, ‘CHARITY’, ‘THOUGHT’, and ‘HOPE’). Participants were instructed to respond when the central word referred to a concrete and tangible concept and withhold response when the word referred to an abstract and intangible concept. Thus, similar to the first two experiments, words associated with up or down signified test trials, in which participants were required to respond to the targets, while neutral words signified catch trials, in which participants were required to withhold response. Both short and long cue-target SOAs (i.e., a randomly chosen duration between 200 to 400 ms and between 800 and 1200, respectively) were used within a single target discrimination task.

Design
Each participant performed a block of a target discrimination task, which consisted of 20 practice trials and 288 experimental trials (192 test trials and 96 catch trials). Cue category (i.e., up, down, neutral), cue identity, target location, and target identity, and SOA category (short vs. long) were randomized such that each combination was equally likely on any given trial. For data analysis, test trials were divided into cue-target compatible and incompatible groups.

### 6.2 Results and Discussion

Few errors were made on catch trials (4.8%), indicating that participants were processing the cues and withholding response on catch trials. Response time data from all the correct trials were trimmed (in the same manner as previous experiments) and were submitted to a 2 x 2 repeated measures ANOVA with SOA (short vs. long) and trial type (compatible vs. incompatible) as independent factors. This ANOVA only revealed a main effect of SOA \[F(1,23) = 50.0, \text{MSE} = 770, p < .001, \eta^2_p = .685\]. Responses on average were slower on trials with short SOAs \(M \pm SE = 535 \pm 12 \text{ ms}\) compared to trials with long SOAs \(495 \pm 13 \text{ ms}\). Neither a main effect of trial type nor a two-way interaction was found \([Fs < 1]\). With both SOAs, there was no difference between cue-target compatible \(535 \pm 13 \text{ ms and } 495 \pm 13 \text{ ms, for short and long SOAs, respectively}\) and cue-target incompatible \(536 \pm 12 \text{ ms and } 496 \pm 12 \text{ ms}\) trials.

Error data were submitted to a similar 2 x 2 ANOVA. This analysis revealed no main effect of SOA \[F(1,23) = 5.41, \text{MSE} = .001, p > .1, \eta^2_p = .058\], although average error rates were higher with short SOAs (4.7%) than with long SOAs (3.9%). The analysis did reveal a main effect of trial type \[F(1,23) = 5.41, \text{MSE} = .001, p < .05, \eta^2_p = .190\], with higher error rates on compatible trials (5.1%) than on incompatible trials (3.6%). The two-way interaction did not reach significance \([F < 1]\). Despite the absence of a two-way interaction, we had a priori reason to expect a larger effect of compatibility with short SOAs (based on Experiment 3; and, Estes et al., 2008). In fact, disadvantage for cue-target compatible trials that is not sensitive to SOA would be hard to interpret as the inhibition effect in question. Thus, we examining the two SOAs separately and found that the effect of trial type was only significant for trials with short SOAs \[t(23) = 2.11, SE = .008, p < .05\] and not for trials with long SOAs \[t(23) = 1.39, SE = .007, p > .1\]. These data are summarized in Figure 6.
Although there was no effect of cue-target compatibility in the RT data, the pattern found in the error data replicated the findings of Experiment 3, and more importantly demonstrated that the disadvantage for compatible trials does not disappear when a) the number of cues in the experiment are reduced, and b) when cues are categorically evaluated prior to performing a response. Concept type appears to be the most critical factor in determining whether implicit spatial cues result in inhibited or facilitated target processing in locations compatible with the concepts.
7 General Discussion

When employing implicit spatial cues, which include words referencing objects with typically perceived locations (e.g., "hat", "boots") or abstract concepts that are metaphorically associated with locations (e.g., "God", "Devil"), both facilitation and inhibition of visual target processing have been observed at cue-compatible locations. In fact, both effects have been reported as evidence in support of a visuospatial bias toward the compatible location. Replicating and extending the findings of two representative studies that have reported facilitation (Chasteen, Burdzy & Pratt, 2010) and inhibition (Estes, Verges & Barsalou, 2008), the present study attempted to specify the conditions in which implicit cues can cause facilitation and inhibition.

First, we examined the findings of Chasteen et al. (2010) who reported facilitated target processing for cue-compatible targets. Experiments 1 and 2 demonstrated that reducing cue-target SOA and using target discrimination do not change the direction of the effects for that task. Next, we replicated and extended the findings of Estes et al. (2008) who reported inhibited target processing for cue-compatible trials. Experiments 3 and 4 demonstrated that inhibition only occurs during the discrimination task in the condition with short SOAs. Importantly, facilitation was not observed in the task used by Estes et al. (2008), even when using the target detection task and long SOAs. Finally, although we did not see any RT effect in Experiment 5, the error data suggested that the inhibition effect can still occur even when the number of cues is reduced and making responses is contingent upon cue category. Thus, we ruled out visual task (detection vs. identification), timing (short vs. long SOAs), and cue treatment (passive viewing vs. category judgment) as predictors of the direction of the effect. Instead, we propose that the type of concepts used in the two studies are responsible for determining the direction of the effects. In particular, it seems that processing concrete concepts associated with visual-perceptual information causes inhibition, whereas processing abstract concepts, which are metaphorically associated with space, causes facilitation on compatible trials.

Delineating the distinct effects of different concept types paves the way toward understanding the nature of their representation and to further specifications of a perceptual theory of concepts. The influential theory of perceptual symbol systems (PSS; Barsalou, 1999; 2003; 2008; Barsalou et al., 2003) has gain much support from the findings of interaction between conceptual processes and concurrent visuospatial processes. It should be noted that the theory in its current form is outlined in relatively general terms partly because PSS was
originally presented as an argument against the traditional view of concepts that did not assume such close association between higher-level and lower-level cognition (e.g., Fodor, 1975; Pylyshyn, 1984). The traditional view held that once concepts are acquired, they become independent from sensorimotor, modality-specific brain mechanisms. Particularly influenced by the computer metaphor of the mind, it was thought that conceptual knowledge could - in principle - be implemented in an abstracted semantic network, without a formative role attributed to its supporting hardware (see Clark, 1997; Barsalou, 1999).

Because the PSS theory was outlined in such broad terms, it would gain support virtually whenever an instance of interaction between a conceptual task and irrelevant perceptual features of the task were observed. Many studies documented such observations with spatial features, showing how semantic decisions with word stimuli (i.e., abstract and symbolic representations of concepts) are affected by the location or arrangement in which the words are displayed (e.g., Pecher et al., 2010; Šetić & Domijan, 2007; Schubert, 2005; Zwaan & Yaxley, 2003). Thus, the basic principle of PSS has been supported: the brain seems to rely on lower-level mechanisms, including visuospatial attention, for thinking and reasoning about concepts. Put differently, concepts are retrieved via reactivation of the pattern of neural activity present during the acquisition of the concepts and sensorimotor interactions with the concepts' referents. This reactivation is also referred to as simulation (Barsalou, 1999). Hence, retrieving the concept of hat means, in part, reactivating the perceptual information associated with seeing hats. Part of this perceptual simulation of hat is a visuospatial bias toward locations above the horizontal meridian.

The explanatory scope of PSS is greatly increased once it is viewed in association with conceptual metaphor theory of cognitive linguistics, which explains how the same perceptual and sensorimotor systems are utilized to make thinking and reasoning about abstract concepts possible, even though many abstract concepts have no direct perceptual correlates (e.g., Lakoff, 1987; 2008; Lakoff & Johnson, 1999; Gallese & Lakoff, 2005). Once this connection is made, PSS can explain conceptual processing ranging from those involving physical objects to more abstract concepts such as magnitude (Fischer et al., 2003), time (Weger & Pratt, 2008), valence (Meier & Robinson, 2004), power (Schubert, 2005), or divinity (Chasteen et al., 2010: Meier et al., 2007; see also Lakoff & Johnson, 1999; Meier & Robinson, 2005). In particular, the close association between many abstract concepts and locations in space suggests that space and spatial cognition may have a central role in the emergence and development of higher level
conceptual skills (Chatterjee, 2001; Coslett, 1999; Hubbard et al., 2005). In fact, the neuropsychological evidence suggests that regions in the posterior parietal lobe underlying spatial cognition may also underlie cognition of numeric order, magnitude, and time (Cohen Kadosh & Henik, 2006; Hubbard et al., 2005; Walsh, 2003; but see Kemmerer, 2005). The sensitivity of the visuospatial attentional mechanisms to number and time cues (Fischer et al., 2003; Ouellet et al., 2010; Weger & Pratt, 2008) are both consistent with the centrality of space in conceptual representation and, more generally, with perceptual theories of concepts.

Understandably, however, the initial steps toward testing PSS did not differentiate between the kinds of interactions that arise from concurrent conceptual and perceptual tasks. Assuming that the interactions between conceptual and perceptual processes do occur, we can now go beyond the initial tests of PSS and investigate the details of these interactions.

At first, it would be tempting to entertain a uniform mechanism of representation that would apply to both concrete and abstract concepts. There are, however, reasons to doubt such uniformity, based on several studies that suggest the essential features involved in the two kinds of concepts differ. Specifically, activation of concrete concepts is thought to invoke richer perceptual features, whereas abstract concepts invoke emotional and introspective states (Kousta et al., 2011; Wang et al., 2010; Wiemer-Hastings & Xu, 2005). Representational features may vary even among comparable conceptual categories causing distinct interaction with concurrent perceptual processes. For instance, Dodd et al. (2008) showed that the spatial bias induced by numbers (i.e., abstract symbols of magnitude) cannot be observed with other ordinal stimuli (e.g., days of the week, months, letters of alphabet), unless participants are instructed to evaluate the relative ordinal value of the stimuli. Surprisingly, and seemingly in contrast, Pecher and Boot (2011) have recently argued that engaging in a relative magnitude judgment (high vs. low) task can produce reliable effects on visuospatial attention only when magnitude is described in concrete terms. In their concrete conditions, the authors instructed participants to evaluate relative magnitude in a particular and concretely described situation (e.g., "The man had two books in his bookcase"), whereas in their abstract condition, they instructed participants to evaluate the magnitude of numbers relative to a given quantity (e.g., "50"). Results showed upward and downward (or rightward and leftward) visual biases after correct evaluation of high and low magnitude, respectively. These effects, however, were not reliable when only numbers were presented. Although the findings do not seem conclusive as to whether abstract symbols of quantity are able to generate reliable visuospatial bias, both studies point out a possible and
important distinction between concrete (i.e., stimuli associated with features additional to magnitude) and abstract (only magnitude, i.e., a number) forms of cue presentation. Although in the present study we have discussed the distinction between abstract and concrete concepts in a different sense, the commonality between the mentioned studies and our discussion is the perceptual information associated with the cue stimulus.

In the context of the present study, the distinction between abstract and concrete concepts is a) defined loosely and a priori based on whether or not they referred to objects of perception, and b) defined post hoc based on the opposite effect they seem to have in very similar spatial cuing tasks. It would be worthwhile to map this speculative distinction onto the mechanisms of visuospatial attention. Theories of visual attention (e.g., Bundesen, 1990; LaBerge & Brown, 1989; Logan, 1996) often make a clear distinction between spatial selection and perceptual identification (see also Johnston, McCann, & Remington, 1995; Remington & Folk, 2001). In Bundesen's (1990; Bundesen, Habekost, & Kyllingsbæk, 2005) theory, for instance, spatial orienting toward a location, thought to be supported by the posterior parietal region and the pulvinar, is modeled distinctly from perceptual expectation/bias, thought to be supported by the ventral visual stream.

One could imagine that implicit cues used in the present study have distinct and simultaneous effects on the spatial orienting and perceptual biases. On the one hand cues referring to both concrete and abstract concept may generate a spatial bias due to the activation of the spatial information in the cue (i.e., simulation), via an increase in the firing rate baseline of cells responding to the cue-compatible location. On the other hand, cues referring to concrete concepts also activate the perceptual information associated with their referents, which generate a perceptual bias that is strongest in the attended location. Cells in the ventral stream that respond to the identity of objects (e.g., image of a hat), simulation of the visual objects, or visual target ('X' vs. 'O') have large receptive fields and, thus, simultaneous representations linked to one area in space inhibit one another (Bundesen et al., 2005; Desimone & Duncan, 1995). Because of the perceptual information associated with the concrete concepts they compete for representations by these cells, which in turn leads to the inhibition of visual target processing (since they appear second in the trial). This competition would be reduced given enough temporal distance between the cue and the target, which leads to the elimination of the effects with long SOAs (Experiment 4). This simple interpretation assumes a similar spatial bias caused
by both types of concepts, with differing consequences attributed to the additional activation of specific perceptual details associated with concrete concepts.

It is also possible that the spatial biases caused by the abstract concepts used in the present study were stronger than those caused by the concrete concepts. Based on the present findings alone, we cannot rule out this possibility. We are, however, currently conducting studies on various interactions between different types of conceptual processing and other factors known to influence spatial bias (e.g., gaze cues, exogenous luminance cues) in order to determine the nature of the cuing effect caused by concepts. In short, a lack of interaction with direct spatial cues seems to suggest that the processes of the spatial bias via implicit cues differ from those that underlie more direct cues of attention. A recent fMRI demonstration by Quadflieg and her colleagues (2011) supports this idea. In that study, the activation of the parietal regions thought to be involved in spatial cognition were compared during three tasks involving perceptual localization ("does the object appear to be above or below?"), semantic position judgment ("is this word associated with up or down?"), and valence-based judgment ("is this an emotionally positive or negative concept?" a semantic category known to produce spatial biases; Meier & Robinson, 2004; 2005). The researchers found distinct activation in the left intraparietal sulcus (IPS) and the right supramarginal gyrus (SMG) associated with valence-based evaluations, whereas activation of the left angular gyrus (AG; this area was also associated with perceptual localization) and the entire left inferior parietal lobe (IPL) associated with semantic positional evaluation. Although the different evaluation criteria used in the three tasks makes interpretation difficult, this study suggests that the spatial processes linked to different conceptual and perceptual processes operate based on cognitive and neurologically distinct mechanisms. This is not surprising since even at the level of basic sensorimotor interaction with the environment, the brain maintains multiple spatial representations anchored to different body parts and the surrounding objects (Colby & Goldberg, 1999). It seems more than plausible, then, that the processes of percepts, concrete concepts, and abstract concepts engage representations of space that are, at least partially, distinct (Kemmerer, 2005).

We propose that the various interactions between conceptual and perceptual processes should be studied in ways that allow for the examination of different conceptual representations. Although our present distinction (concrete vs. abstract) may be simplistic and dichotomous, it invites further work on the degree to which concepts are perceptually or metaphorically associated with locations in space. At this point, there are few who would argue against the general principles of
PSS, that concepts are possible because of the simulations and that activating a concept representation necessarily involves the perceptual, sensorimotor, or affective context relevant for to that concept (Barsalou, 2008; Barsalou et al., 2003; Šetić & Dominjan, 2010). It is not clear whether, and to what extent, these processes qualitatively differ due to the differential contributions of the lower-level cognitive components.
References


