CAN SEMANTIC ACTIVATION AFFECT FIGURE ASSIGNMENT?

by

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DEDICATION

I dedicate my dissertation to my parents for encouraging me to be curious about everything.

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Abstract

Figure assignment entails competition between object properties on opposite sides of borders. The figure is perceived on the side of the border that wins the competition. Ample evidence indicates that configural familiarity is among the competing object properties. We investigated whether priming the semantics of a familiar object suggested along one side of a border can increase its likelihood of winning the competition. To prime the semantics, we presented brief masked exposures of object names before brief masked exposures of displays where a portion of a familiar object was suggested on one side of a central border separating two equal-area, black-and-white regions. Participants reported whether the figure lay on the left or right side of the central border and were unaware of the presence of the word prime. These experimental primes named either the Same Object (SO) or a Different Object (DO) as the familiar object suggested in the display. In the DO condition, the word named an object either in the Same Category (DO-SC) or a Different Category (DO-DC) as the familiar object suggested in the display, where superordinate category was defined as natural versus artificial objects. We also used non-words as control primes. We hypothesized that, if semantic activation influences figure assignment, participants in the SO and DO-SC conditions should be more likely than participants in the DO-DC condition to perceive the figure on the side where the familiar object lies following experimental primes than control primes. We did not observe differences between experimental and control prime in any condition. However, we did obtain a *Prime Context Effect*, in that participants were more likely to perceive the figure on the familiar side of the border in the SO and DO-SC conditions than in the DO-DC condition. The Prime Context Effect shows that participants discerned the relationship between the masked word prime and the semantics of the familiar object

suggested in the display, and this led them to change their strategy on both experimental and control trials. We also found that behavior changed over the course of the experiment: Participants in the DO-DC condition perceived the figure on the familiar side of the border more often in the second half of the experiment, on both experimental and control trials. This pattern suggests that over the course of the experiment, they learned to rely more on information from the display than from the prime, perhaps by restricting their attention to the time when the figure-ground display appeared. Participants in the DO-SC condition perceived the figure on the familiar side of the border more often on experimental trials in the second half of the experiment, whereas their performance on control trials did not differ in the first and second half. We hypothesize that participants in the DO-SC condition learned to match the superordinate semantics of the experimental prime and the display, leading to semantic priming. Taken together, these results show that (1) participants can quickly learn the relationship between experimental primes and target displays and can change their strategy accordingly, and (2) semantic activation can affect figure assignment.

Introduction

The world is populated with meaningful objects, from the universally recognized human form to idiosyncratic art with no resemblance to the natural world. The brain continuously creates and maintains memories of the various objects; these memories may originate from direct experience (e.g., interacting with a domesticated cat) or from indirect experience (e.g., viewing a pictorial or lexical representation of an extinct species). These object memories help mold the foundation of semantic knowledge that represents the enormous reservoir of facts that one accumulates about the world and is at the core of cognition, which is ultimately responsible for how the brain can recognize and remember objects (Moss, Tyler, & Taylor, 2007). The semantics of objects is theorized to be componential in nature; that is, semantics is comprised of smaller units of meaning that can be broken down into attributes, properties, and features (Moss, Tyler, & Taylor, 2007; Taylor, Devereux, & Tyler, 2011). For example, the concept of a domestic cat includes its category(ies) (a living entity; a common pet), its distinguishing features (e.g., the distinctive vocalization of a cat's meow), and features it shares with other living entities (e.g., has eyes),.

Thus, the semantic network is an indispensable cognitive system for understanding the meaning of stimuli. From pure phenomenological observations, the meaning and form of objects appear tightly coupled. For example, it is almost impossible to view only the physical shape of objects or written words in one's lexicon without automatically interpreting their meaning. Therefore, a fundamental question is how the brain integrates the form and the meaning of objects. It is commonly assumed that two separate, sequential stages of processing are involved: first, a stage at which the geometric shape of an object is determined and then a stage at which the meaning of an object is accessed. The brain uses a set of perceptual organizing heuristics to determine what properties and features constitute an object. Figure-ground segregation is a well-studied form of perceptual organization that is relevant to object perception.

Figure-ground perception occurs when two regions sharing a border are perceived such that one region (the figure), has a definite shape and appears to be nearer than the other region at their shared border whereas the other region appears shapeless and simply appears to continue behind the figure at the shared border (this region is the ground). Figure assignment is contingent on different shape and depth properties (Goldreich & Peterson, 2012; Kanizsa, 1979; Kimchi, Behrmann, & Olson, 2003; Kubovy & Pomerantz, 1981; Palmer, 1999; Peterson, 2003; Pomerantz & Kubovy, 1986) often called "cues". The Gestalt psychologists called these shape cues "configural cues" because they provide information regarding where configurations (i.e., figures) lie in the visual field. Classic Gestalt configural cues include convexity, symmetry, small area, and enclosure. The Gestalt psychologists, as well as other modern researchers (e.g., Biederman, 1987), espoused the "figure-first assumption" in that the initial step in object perception is figure assignment; they considered the meaning of an object to be a secondary characteristic. This is based upon the assumption that all objects in the world have certain geometric properties/components in common (e.g., classic Gestalt configural cues).

Furthermore, objects are theorized not to become perceptual objects until attention is focused on the features constituting them. Before focused attention, objects are considered "proto-objects", which are volatile units of visual information that have the potential to be bound into coherent and stable objects (Rensink, 2000). On this traditional view, object memories are accessed and the semantic network is activated only after figure assignment is achieved. The "New Look" movement during the1940s and 1950s, however, entertained the possibility that cognition and perception co-occur and interact instead of operating sequentially.

The New Look movement attempted to investigate contributions of emotion, knowledge, expectation, and motivation to perceptual organization, including figure assignment. For example, Schaffer & Murphy (1943) tested whether the valence associated with previously learned novel stimuli could affect figure-ground segregation. Schaffer and Murphy used ambiguous stimuli that depicted two profile faces abutting one another at a central border in a circle (see Figure 1B). The stimuli were designed so that perceiving one face meant that region was the figure and the abutting region was the ground. Prior to the main experiment, participants were told they were going through a learning experiment and had to learn to associate four different names with four unambiguous faces presented sequentially (see Figure 1A). Some faces were paired with a modest monetary reward while others were paired with a modest monetary loss. After the learning experiment and unbeknownst to their participants, the experimenters tested participants' knowledge on how well they remembered the faces without the immediate association of reward or punishment. They were asked to call out the names of the faces they perceived when viewing the ambiguous displays in which faces previously paired with positive (reward) and negative (loss) valence abutted each other at the central border. Schaffer and Murphy found faces that were rewarded with money during learning were named more often than those that were paired with a modest monetary loss.

They took these data as evidence that positively rewarded faces were more likely to be seen as figures than negatively associated faces.

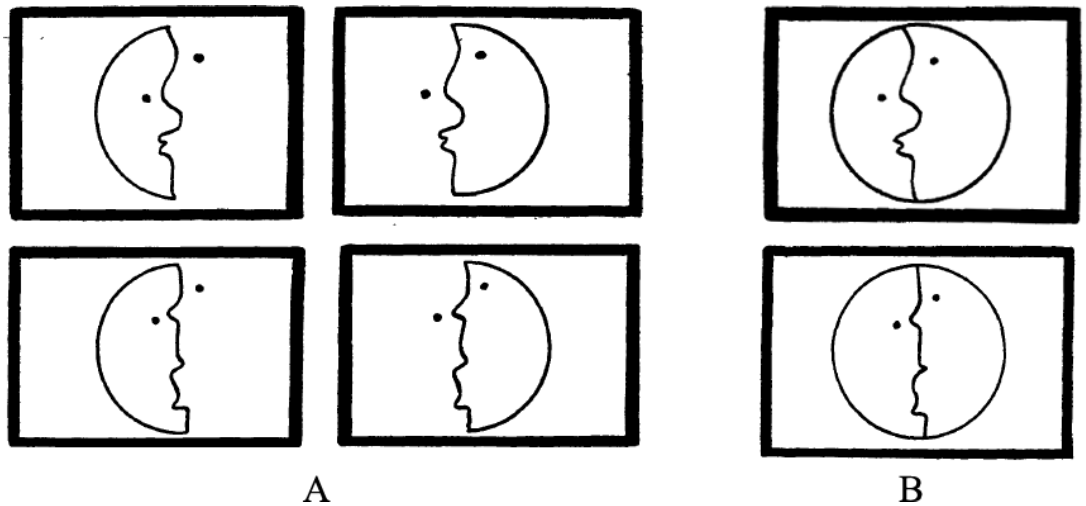


Figure 1
Stimuli were taken from Schaffer and Murphy (1943). Figure 1A: unambiguous faces that were associated with either a positive or a negative valence during the learning portion of the experiment. Assume for now that the faces in the left column were associated with positive reward whereas those in the right column were associated with negative valence. Note that within a row, the stimuli in the left and right columns are complements in that they are sketched on opposite sides of the same border (and would fit together like jigsaw pieces). Figure 1B: ambiguous stimuli that contain both positive and negative valence faces.

A major criticism of Schaffer and Murphy and other New Look movement studies was that the results could have been due to response bias. A response bias is an unintentional consequence from the design of the experiment in that participants have a tendency to respond in a certain way (e.g., inflating a measure of self-worth) that obscures the data in any given paradigm. An example of a response bias in the context of Schaffer and Murphy is that their participants might simply be more biased to report rewarded faces, regardless of whether or not they were perceived as figures first. Smith and Hochberg (1954) replicated Schaffer and Murphy's effect and demonstrated that the test exposure duration was long enough for reversals of figure assignment. Because participants could report both faces within the test exposure, Smith and Hochberg argued they might simply be more biased to report the rewarded face as the figure, reflecting more of a strategy than an effect of immediate past experience on figure assignment. However, Smith and Hochberg's argument does not eliminate the possibility that the first percept was affected by the main manipulation of the experiment, which would support Schaffer and Murphy's claim (Peterson, 1999). Smith and Hochberg's hypothesis could have been tested by presenting the stimuli for durations too short to support a reversal but this possibility was never fully investigated.

Another limitation with the New Look movement was not carefully specifying the degree to which they thought the visual system was "cognitively penetrable" (i.e., could be affected by high-level knowledge). Some authors argued that if the visual system is completely cognitively penetrable percepts are likely to be confabulated without consistency or relation to the external world (e.g., Pylyshyn, 1999). The interpretation of the visual world must be generally consistent across different observers. Effective communication is largely dependent on the ability to have some basic understanding of what the other person is experiencing. This lack of specifying the degree of cognitive penetrability affected the argument that higher-level cognition can affect perception; thus, the dogma that figure assignment precedes access to object memories persisted over many years.

Models that advocated a more linear and modular view to explain how we perceive meaningful objects were more readily accepted. For example, David Marr (1982) is an often-cited author who proposed that vision builds up in complexity through progressive steps. Marr took into account that the cortex is assembled in a layered series of representations that eventually form into representations of the visual objects in the external world. His proposed hierarchical model of vision is based on the premise that each level of visual processing is improved in a linear sequence. Within each level, the algorithm and output are unique. According to Marr's theory, vision begins at a low-level where there is a primary sketch that represents the basic features and spatial relations. Then what follows is an "intermediate-level vision" in that there is a 2.5 D sketch that represents the surfaces and shapes from the observer's viewpoint. Finally, there is high-level vision that combines a full 3-D structure and various components of an object together to create the phenomenological experience of viewing a 3-D object model. Other modern models of vision after Marr continued to endorse a similar linear "feed-forward" view (e.g. Fabre-Thorpe, Delorme, Marlot, & Thorpe, 2001; Serre, Oliva, & Poggio, 2007; Thorpe, 1994).

Peterson and colleagues challenged Marr's and other linear models by addressing the fundamental assumption that object memories are accessed only after figure assignment has occurred. Peterson and colleagues provided ample evidence that object memories are accessed sufficiently early to affect figure assignment. With all configural cues being equal, such as the amount of convexity and area, Peterson Harvey, & Weidenbacher (1991; Gibson & Peterson, 1994; Peterson & Gibson, 1993; 1994a; 1994b) demonstrated that the figure is likely to be assigned to the side of a border where there is a suggestion of a familiar object (see Figure 2A) when that object is depicted in its upright, familiar, orientation rather than in an inverted unfamiliar orientation. They found that the side of a border where a portion of a familiar object is suggested is more likely to be obtained as figure and is maintained as figure longer when the familiar configuration is suggested in its typical or upright orientation rather than an atypical inverted orientation (Gibson & Peterson, 1994; Peterson, Harvey & Weidenbacher, 1991; Peterson

& Gibson, 1994a & 1994b). If the figure-first assumption is correct and object memories are accessed only after figure assignment, there should be no orientation-dependent effect of objet memories on figure assignment because the configural cues (e.g., convexity) are unaffected by a change in orientation. The results reported by Peterson and colleagues demonstrated that object memories are accessed before figure assignment and affect the outcome, thereby refuting the figure-first assumption. Furthermore, these effects were obtained when the parts of the familiar object were arranged in their proper spatial relationship and not when they were rearranged (compare Figures 2A and 2C below; Gibson & Peterson, 1994; Peterson, et al., 1991). Consequently, these familiarity effects involved high-level representations where receptive fields are large enough to encompass whole configurations. Indeed, Barense, Nigo, Hung, & Peterson (2011) reported that the perirhinal cortex (PRC), a high-level medial temporal lobe (MTL) structure assumed to be primarily involved with memory, is involved in these effects of familiar configuration on figure assignment.

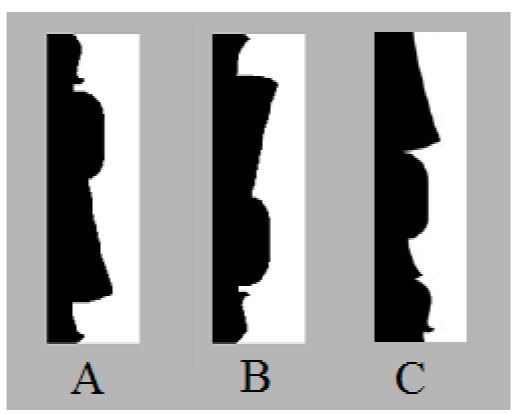


Figure 2

Figure 2.A) The black region depicts a standing woman in its canonical orientation. B) The black region is the same image of the woman, but the orientation of the display is rotated 180°. C) The black region is composed of the parts of the woman rearranged into a novel configuration. The Gestalt figural cues are the same in all of the displays, but object memories are associated with A.

Recently, Peterson, Cacciamani, Mojica, and Sanguinetti (2012; Cacciamani, Mojica, Sanguinetti, & Peterson, under review; Sanguinetti, Allen, & Peterson, 2014) showed that, contrary to linear models of vision, object semantics are accessed before figure assignment. Peterson et al. (2012) showed that high-level semantic knowledge is accessed by regions of a display that are ultimately perceived as grounds. They used small, enclosed, novel black silhouettes as stimuli (see Figure 3). Portions of real world/meaningful objects were suggested on the outside of the borders of these silhouettes, but observers did not see them – they perceived the outsides as shapeless grounds to the black silhouettes.

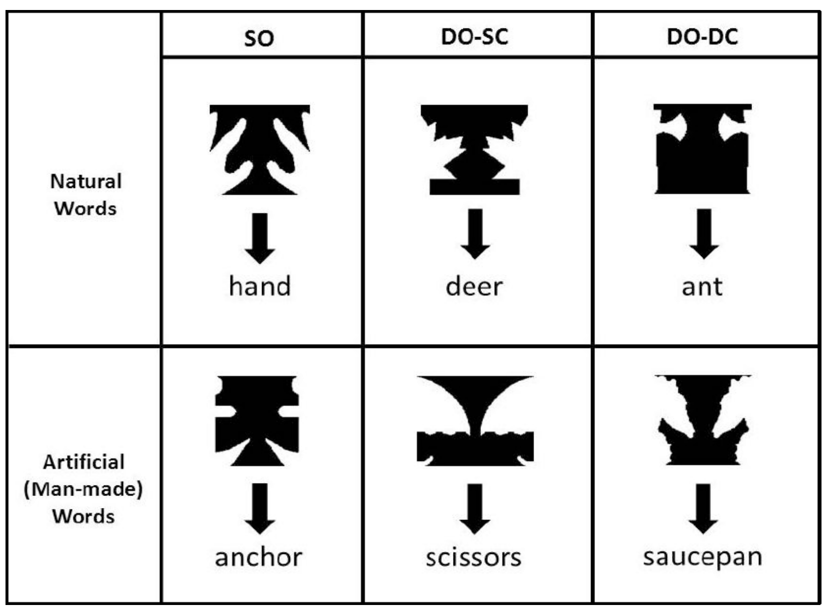


Figure 3

Figure 3 is taken from Peterson, Cacciamani, Mojica, & Sanguinetti (2012). The black silhouettes were designed to favor the percept of novel black silhouettes, but portions of familiar objects were suggested on the outside (the groundside) of the left and right borders. Participants were not aware of the familiar objects; hence, we call them "hidden objects." Participants categorized the words as naming natural or artificial objects. The hidden objects on the groundside of the silhouettes could be either semantically related or unrelated to the words. They were either the (Same Object (SO; left column); a Different Object in the Same Category as the object named by the word (DO-SC; middle column where portions of maple leaves are suggested on the outside of the silhouette shown before the word "deer," and portions of umbrellas are suggested on the outside of the silhouette shown before the word, "scissors"), or a Different Object in a Different Category (DO-DC; right column where portions of axes are suggested on the outside *of the silhouettes shown before the word, "ant," and portions of seahorses are suggested on the outside of the silhouette shown before the word, "saucepan.").*

Peterson et al. (2012) asked observers to categorize words as naming natural or artificial objects (e.g., "seahorse" and "anchor" are examples of natural and artificial objects, respectively). Before each word, a unique, novel silhouette with a real world/meaningful shape suggested on the outside was presented briefly for 50 ms. These silhouettes were designed so that the inside would be perceived as the figure and the outside would be perceived as a shapeless ground near the borders it shared with the figure. The silhouettes were small in area, symmetric around the vertical axis, enclosed, and surrounded by a larger area; these factors all favor the interpretation that the inside is the figure. Moreover, on each trial, participants expected a novel silhouette to precede the word, and the silhouette appeared centered on the location where the participants' eyes were fixated (fixation and expectation affect figure assignment; Peterson & Gibson, 1994b). We manipulated the semantic relationship between the target word and the object that was suggested -- but not consciously perceived -- on the outside of the preceding silhouette in three within-subjects conditions: (1) In the Same Object (SO) condition, the target word named the object suggested on the outside of the preceding silhouette; (2) In the *Different Object-Same Category* (DO-SC) condition, the target word named a different object from the object suggested on the outside of the preceding silhouette, but the objects were from the same coarse semantic category in that both were natural objects or both were artificial objects (e.g., target word "deer" followed a silhouette where a leaf was suggested on the groundside; both are natural objects); (3) In the Different Object-Different Category (DO-DC) condition, the target word named a different object from the object suggested on the outside of the preceding silhouette, and the objects were from different semantic categories in that one was natural and the other was artificial (e.g., (the target word “ant” naming a natural object followed a silhouette with the artificial object axe suggested on the outside). (Samples are shown in Figure 3).

Critically, the data are only from participants who were completely unaware of the objects suggested on the groundside, which was assessed during careful post-experiment questioning. Word categorization RTs were faster in the SO and DO-SC conditions relative to a baseline comparison group that categorized the same words alone without preceding silhouettes. Word categorization RTs in the DO-DC condition was longer than those in the other two conditions and did not differ from their baseline group.

These data showed that the meaning of objects, both in terms of structural and semantic knowledge, is not secondary to figure assignment (cf., Peterson & Skow, 2008). Rather semantic access occurs for objects that might be seen in regions that are ultimately determined to be grounds. The priming Peterson et al. (2012) observed is similar to other priming effects observed when masked words or figures prime semantically related targets (e.g., Finkbeiner, Forster, Nicol, Nakamura, 2004; Dehaene et al., 1998; Dell’Aqua & Grainger, 1999; for review, see Van den Bussche, Van den Noortgate, & Reynvoet , 2009). Thus, Peterson et al.’s key contribution is that potential objects that are suggested on the groundside of a border –but not consciously perceived – can activate the semantic network. These data are consistent with the claim that semantic information is quickly extracted in visual scenes (e.g., Apfelbaum, Blumstein & McMurray, 2011; Kirchner & Thorpe, 2006; Thorpe, Fize, & Marlot, 1996) and without awareness of the object (Fahrenfort, Snijders, Heinen, van Gaal, Scholte, & Lamme, 2012; Koivisto & Revonsuo, 2007; Sanguinetti, Allen, & Peterson, 2014).

Thus, the semantics of an object that might be present in a display are rapidly extracted and can affect responses to a word categorization task that immediately follows the visual displays. However, it is not known whether activation of semantic category information affects figure assignment, or whether semantic activation is irrelevant to figure assignment.

Gibson and Peterson (1994) showed that the prior presentation of the shape of an object suggested on one side of the border of a subsequent figure-ground display increased the likelihood that observers would perceive the figure on the side of the border where the familiar object lay. Thus, the prior activation of the structure of an object potentially present in a figure-ground display affects the perception of that display. It is possible the same is true for the prior activation of non-structural aspects of the semantics of the object (i.e., the coarse category of the object) as well. In the following experiments, we used a masked priming paradigm to investigate whether priming the coarse semantics of an object would have a functional consequence on figure assignment. We presented masked words before bipartite displays that had a portion of a familiar object suggested on one side of a central border separating two equal area black and white regions. The words either named an object in the same semantic category as the familiar object suggested in the display or a different object. Participants' task was to report whether the figure lay on the left or right side of the central border. The method is described in more detail below.

Experiment 1

Design

As in Peterson, et al. (2012), there were three types of word-silhouette pairs: (1) same object (SO), (2) different object/same category (DO-SC), (3) different object/different category (DO-DC). In the SO condition, the word prime named an object with the same shape and semantic category as the familiar object potentially present in the figure-ground display (e.g., dog-dog). In the DO-SC condition, the word prime did not name the object but did name an object from the same semantic category (natural/artificial) of the familiar object potentially present in the figure-ground display (e.g., arm-dog). In the DO-DC condition the word prime did not name either the familiar object potentially present in the figure-ground display or an object from the same natural/artificial category (e.g., car-dog). In addition to the real word primes that were used in each of these experimental conditions, non-word primes were used as controls for each of these conditions (See Figure 4). The same non-words were used for all three control conditions. They were created from a different set of real words that matched the number of characters of the SO words. Two of the letters of these real words were changed (either 2 consonants, 2 vowels or 1 consonant and 1 vowel) to prevent the non-words from being perceived as real words with the letters (consonants or vowels) switched. For example, using 1-consonant-and-1-vowel change rule, the stem word “pie” was changed to the non-word “jia”. Condition (SO, DO-SC, & DO-DC) was a between-subjects factor and Trial Type (experimental/ real words & control/non-words) was a within-subjects factor. Note that the same control non-words were presented to all participants.

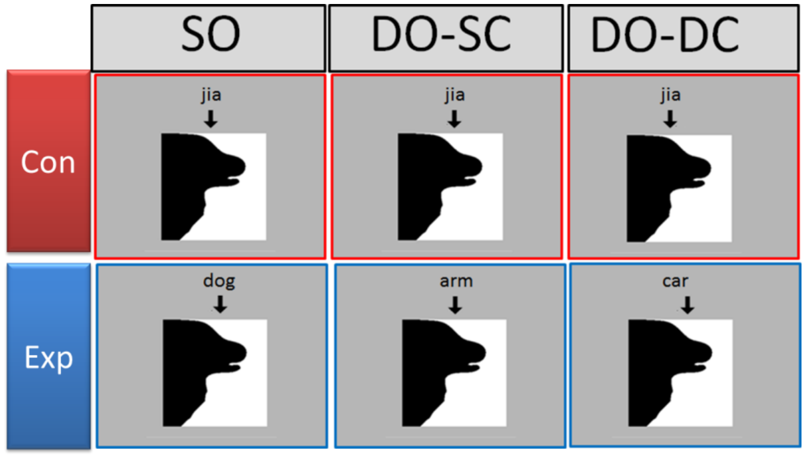


Figure 4
Figure 4 is an example of the overall structure of the design. The figure-ground displays depict a portion of a dog, which is black and located on the left in this sample. The color and location of this critical region were balanced in the experiment. The three columns represent the three conditions (SO, DO-SC, DO-DC). The top row represents control trials that are paired with non-words while the bottom row represents experimental trials that have different word primes.

The word masking paradigm was adapted from Finkbeiner et al., 2004 (see Figure 5). Specifically, the word prime was presented between a forward mask and a backward mask. The forward mask consisted of 15 repeats of the characters "#" and was presented for 500 ms. The word prime (e.g., "guitar") was presented for 50 ms and then was immediately masked by a unique, nonsense string of mixed uppercase and lowercase characters (e.g., "HdLppG") that matched the character length of each word. The masked word paradigm is described in more detail in the procedure section.

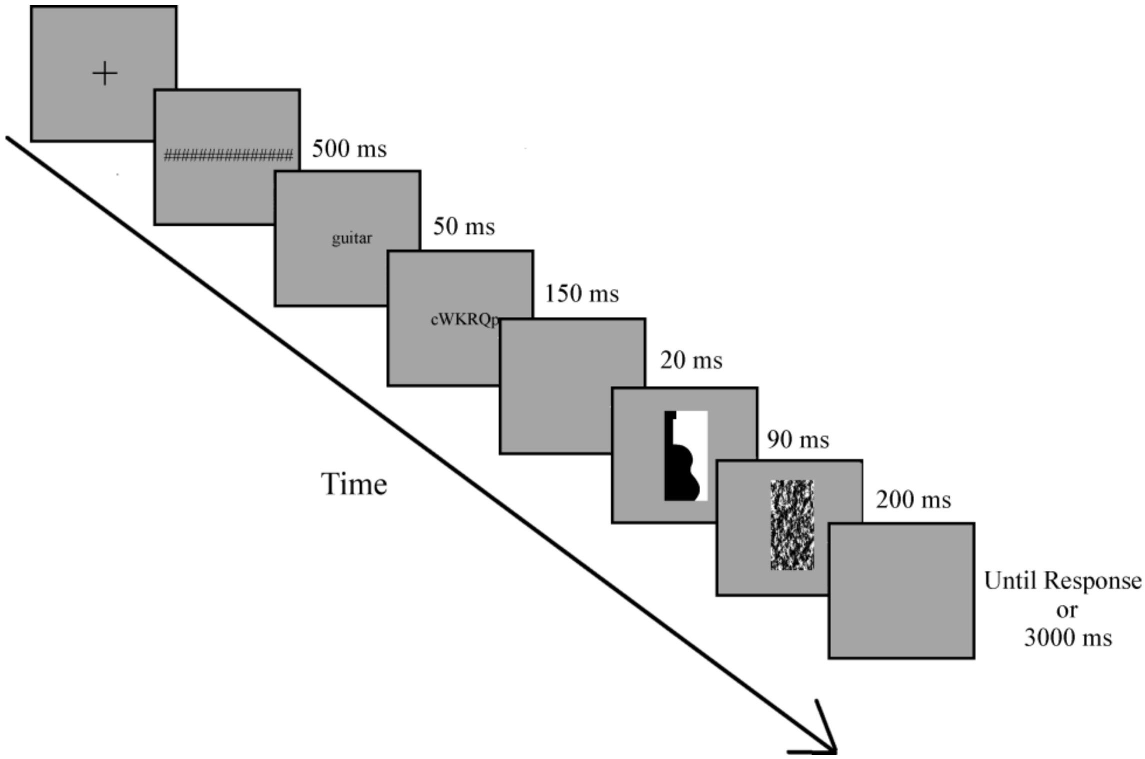
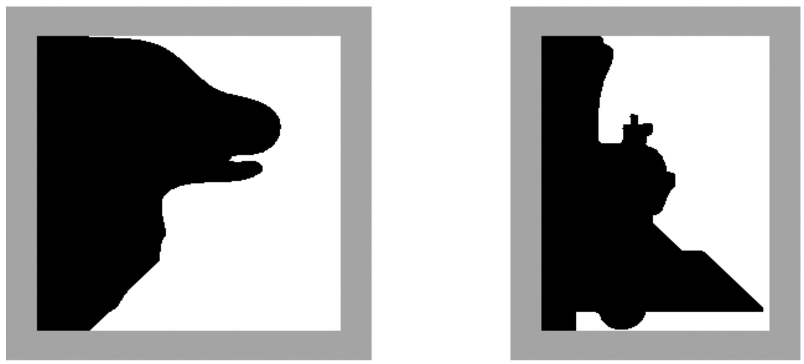


Figure 5

Figure 5 represents the sequence of a single trial. The example is in the SO condition: the word prime "guitar" names the familiar configuration in the bipartite display. The trial begins with a fixation point that is controlled by the participant and then with the following sequence: forward mask (####) 500 ms, a word prime 50 ms, backward mask 150 ms, ISI 20 ms, figure-ground display 90 ms, and figure-ground display mask 200 ms. A gray screen remained until participants made a figure-ground report or until time out (3000 ms).

Stimuli

The figure-ground displays were bipartite displays in which a central border divided a rectangle into two equal-area regions. A portion of a familiar object was sketched on one side (left or right) of the central border (See Figure 6). There were 32 unique displays. These displays were balanced for the color of the region portraying a portion of a familiar object (black and white) and side (left or right) of the central border of this critical region. Half of the stimuli depicted natural objects (e.g. dog) while the other half depicted artificial objects (e.g. train). Displays were generated using a program called “Figure-Ground Generator” (J. C. Forster, University of Arizona). Stimuli were an average 5.7° high and 3.1° wide. The word primes were all in Times New Roman fonts, subtending 0.6° high and 1.7° wide.



A B

Figure 6

Figure 6 is a representative sample of the stimuli. The critical regions are both black and on the left region. Color and location were balanced in the experiment. Figure 6A is a depiction of a dog (natural object), and Figure 6B is a depiction of a train (artificial object). The displays were presented on a perceptual medium gray background that covered the entire screen.

Assumptions and Predictions. We assume that when the word prime and the bipartite figure-ground display are presented, structural and category-specific (natural or artificial objects) semantic knowledge is accessed. The residual effect of semantic activation by the prime may affect the speed with which the familiar object in the bipartite display is categorized, provided the stimuli are presented within a short time frame. If semantic activation from the stimuli are used to determine where the figure lies with respect to the central border of the bipartite test display, participants in the SO and DO-SC conditions will be more likely than participants in the DO-DC condition to perceive the regions portraying familiar objects as figures. Semantics may contribute to figure assignment via low-level perceptual features in that natural objects tend to be curvilinear and artificial objects tend to be rectilinear (Kurbat, 1997; Zusne, 1975) and/or via high-level semantic knowledge regarding natural/artificial objects. If an effect is observed it is more likely to arise from high-level semantic knowledge because low-level perceptual features do not distinguish which side of the display has the familiar object, whereas the semantics of the familiar configuration are activated by one side of the display only.

The semantic information likely to affect figural assignment whether the objects are categorized as artificial or natural. Participants were not required to explicitly make this categorization in the current set of experiments, such as in Peterson et al. (2012), but this fundamental category distinction is theorized to be a salient division in the conceptual system. Evidence that living/nonliving objects are represented in partially distinct, sensory and motor based neural network built on category-specific deficits resulting from damage to the temporal lobe (Capitani et al., 2003; Humphreys and Forde, 2001; Martin, 2007.) Kriegeskorte et al. (2008) recently used fMRI to observe patterns of activation in healthy participants, and found that living vs. non-living and natural vs. artificial objects are represented in somewhat non-overlapping regions of the brain.

In the same category conditions (SO & DO-SC), when the word “dog” or “arm” is presented, activation spreads to other natural objects in the semantic network. Thus, when a figure-ground display depicting a portion of a dog on one side of the border is presented, activation within the natural category is enhanced because of residual activation from the preceding word. Because activation from the display arises from one side of the central border, the probability that the critical region is perceived as the figure will be increased if semantic activation can play a role in figure assignment. Likewise, in the different category condition (DO-DC), when the word "car" is presented, the semantic network is theorized to facilitate the processing of artificial objects. When a figure-ground stimulus that suggests a dog (a natural object) on one side of the central region is presented, activation builds up slowly in the natural category because it arrives against a background of artificial semantic activity.

Predictions

If the category of the object named by the word prime matches the category of the familiar object potentially present in the display, as it does in the same object (SO) and different-object same category (DO-SC) conditions, then if semantic activation can affect figure assignment, we expect to see increased reports of the critical region as figure on experimental trials relative to control trials in the SO and DO-SC conditions. The semantic effects might be larger in the SO condition than in the DO-SC condition because the object portrayed by the critical region shares the shape as well as the category with the object named by the word prime in the former condition, whereas it shares only the same category in the latter condition. We also predicted we would see more reports of the critical region as figure in the SO and DO-SC conditions than in the DO-DC condition where the category of the object named by the word prime does not match that of the familiar object suggested in the critical region. No differences were expected to be observed across the three different conditions for the control trials because the non-words were the same in every condition. These predictions are illustrated in Figure 7.

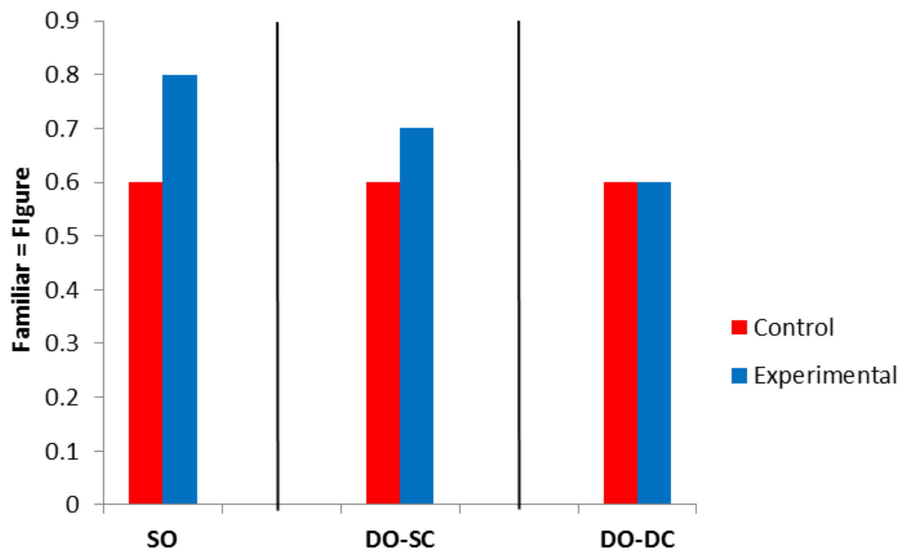


Figure 7

Figure 7 is the predicted outcome of Experiment 1. The y-axis represents the likelihood of perceiving the critical region as figure. Plotted on the x-axis are the three priming conditions: SO (Same Object), DO-SC (Different Object Same Category), and DO-DC (Different Object Different Category). The blue bars represent the predicted data from experimental trials (real word primes), while the red bars represent the predicted data from control trials (non-words).

Participants

All participants were undergraduate students at the University of Arizona who participated in in order to fulfill a requirement of an introductory course; they had normal or corrected-to-normal vision. We restricted the age range of our participants to 18-23 to reduce variability that may be associated with one's age that may inflate or diminish meaningful differences across priming conditions and experiments. There were 115 participants in Experiment 1; of these, 21 participants were excluded from the analysis (2 because they were older than 23, 3 because they reported being aware of the masked primes when questioned about this after the experiment questioning, 12 because they did not meet the response criterion of responding on at least 85% of the trials with a time response window from 200 ms to 3000 ms post stimulus onset, 1 because of difficulty following instructions, and 3 because their responses deviated from their condition mean by more than two standard deviations). Consequently, the data from 96 participants were included in the final analysis: 32 in the SO condition, 29 in the DO-SC condition, and 33 in the DO-DC condition.

Procedure

Participants were assigned to one of the three priming conditions (SO, DO-SC, & DO-DC) when they entered the lab. At the beginning of the experiment, participants read detailed instructions regarding figure-ground perception. They were told that at a border shared by two regions, one was often perceived as a figure, and the other as a ground. The region perceived as a figure would appear to have a definite shape and would seem to be closer in space than the abutting region. Conversely, the region perceived as ground would appear to be shapeless near the border it shares with the figure and would seem to be farther away. They were told that their task was to press a button to indicate whether they perceived the left or right region as figure. Importantly, instructions stressed there were no right or wrong answers and that the experimenters were interested in the participant's first impression regarding figure-ground organization.

Before each trial, participants fixed their eyes on a fixation cross near the center of the screen. When they were ready for each trial to begin, they pressed a foot pedal and the fixation cross disappeared and was immediately followed by this sequence: forward mask (500ms), word prime (50 ms), backward mask (150 ms), inter-stimulus interval (ISI; 20 ms), figure-ground display (90 ms), and post-mask display (200 ms). Participants had 3000 ms to respond by pressing one of two buttons (left or right) arranged horizontally to indicate whether they perceived the left or right region of the figure-ground display as the figure (See Figure 5).

The experimenter was present while participants read the instructions and completed 16 practice trials. None of the stimuli used on the practice trials was repeated during the experiment. Participants were encouraged to ask questions at any time. After the practice trials, the experimenter left the room and the participant completed 64 trials (32 experimental & 32 control trials intermixed) alone. The participants rested their chins on a chin rest to maintain the same viewing distance throughout the experiment. The stimuli were presented on a 21-inch CRT monitor positioned 96 cm from the participant. The presentation software was DMDX (Forster & Forster, 2003). This procedure was the same for all subsequent experiments, except for changes in the number of stimuli and the duration of the figure-ground display.

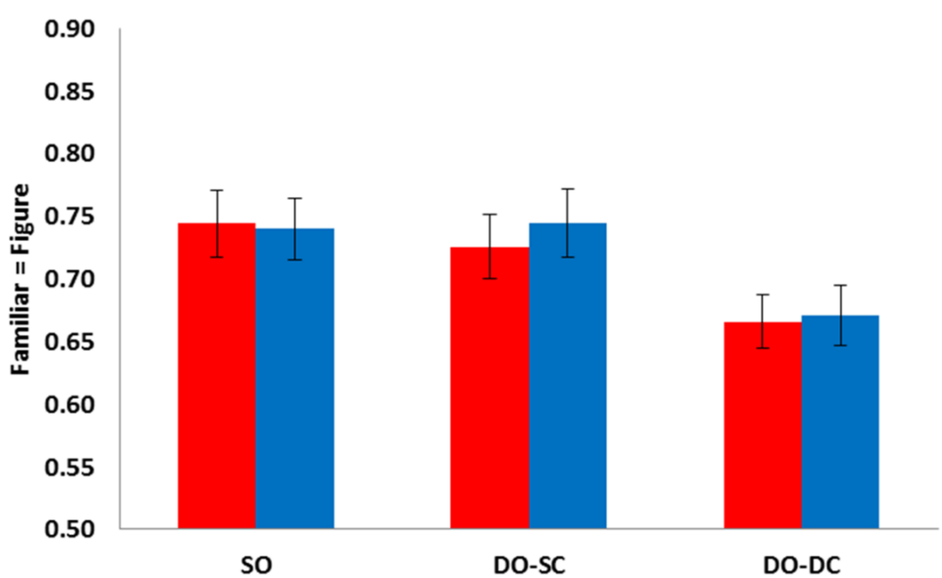


Figure 8

Figure 8. The data from Experiment 1. The y-axis represents the likelihood of perceiving the critical region as the figure. Plotted on the x-axis are the three conditions: SO, DO-SC, and DO-DC. The blue bars represent the data from experimental trials, while the red bars represent control trials.

Experiment 1 Results

An ANOVA was conducted on the percentage of critical region as figure reports with a within-subject factor of Trial Type (experimental vs. control) and a between subjects factor of Priming Condition (SO, DO-SC, & DO-DC). There was a main effect of Priming Condition, $F(2,91) = 3.10$, $p = .050$. As can be seen in Figure 8, participants were more likely to perceive the critical regions depicting familiar objects as figures when the preceding masked word prime named the same object (SO: 74%), or a different object in the same natural/artificial category (DO-SC: 73%) rather than a different object from a different category (DO-DC: 67%). Thus, the prior activation of the superordinate category semantics of an object that might be perceived in a display increases the likelihood that the region portraying that object will be perceived as the figure compared to the prior activation of a different portion of the semantic system. However, there was neither a main effect of Trial Type (experimental vs. control), $F(1,91) = 0.46$, $p = .50$, nor an interaction between Trial Type and Priming Condition, $F(2,91) = .51$, $p = .60$. Thus, the results showed that performance on both experimental and control trials differed with condition. Given that the same non-word primes were used on the control trials in each Priming Condition, we suspected that performance on the control trials was contaminated by the experimental trials. We address this question below by examining how performance on experimental and control trials changed across the experiment.

To examine why performance on control trials differed as a function of experimental condition, we first investigated whether performance on control trials differed as a function of whether participants responded to a given display first following an experimental prime or a control prime. Recall that in each priming condition, each figure-ground display was shown twice, once after an experimental prime and once after a control prime. Given that the organization fitted to a figure-ground display is likely to be the same the second time it is viewed as it was the first time it was viewed (Peterson & Lampignano, 2003), it is possible that the performance on control trials was affected by prior experience with experimental trials and vice versa. That is, if a participant saw the dog as figure on one trial, they would be highly likely to perceive the dog as the figure in the subsequent trial, regardless of whether a real word or a non-word preceded it.

To address this concern, the figure-ground data were reanalyzed to include presentation order. For this order analysis, the trials were grouped into two sets: (Set 1) experimental trials first (control trials second); (Set 2) experimental trials second (control trials first). We conducted an ANOVA with the within-subject factors of Order (Set 1 vs. Set 2) and Trial Type (experimental vs. control) and a between subjects factor of Priming Condition (SO, DO-SC, & DO-DC). There was no main effect of Order nor did Order interact with other variables, $ps > .54$. Thus, the order of presentation of particular stimuli did not have an effect on figure-ground decisions in the control trials. The only effect that was marginally statistically significant in this analysis was Priming Condition, $p = .053$, replicating the effect of Priming Condition found in the overall analysis.

We next examined whether participants learned about the relationship between the primes and the familiar configurations in the bipartite displays over trials in each condition, and therefore assigned different weights to semantic information originating from the target figure-ground displays in the different priming conditions. Specifically, when the semantics of primes and target mismatch, participants might learn to discount any early-arriving semantic activation in assigning figural status (and this would extend to control trials as well as experimental trials), whereas when the semantics of primes and targets match, participants might learn to value or up-weight, early-arriving semantic activation in assigning figural status.

In Experiment 1, participants in each condition viewed 64 randomly intermixed experimental and control trials. To examine learning during the experiment, we binned them into halves of 32 trials: first half = the first 16 experimental and the first 16 control trials; second half = the second 16 experimental and the second 16 control trials[1]. This division represents an important halfway point in learning the relationship between the word prime and the critical region in the target figure-ground display. Depending on the assigned priming condition, participants could either make us of or ignore the semantic activation from the prime of the experimental trials. Using this method, we can get a better sense of whether participants respond differently over the course of the experiment on the experimental trials, the control trials, or both. Moreover, we looked at each priming condition separately to see how the context of experiment affects figure assignment.

An ANOVA was conducted on the percentage of critical region as figure reports with within-subject factors of Trial Type (experimental vs. control) and Half (first vs. second half) and a between-subjects factor of Priming Condition (SO, DO-SC, & DO-DC). There was a main effect of Priming Condition, p = 05 (SO & DO-SC > DO-SC),

[1] For this half analysis, we did not divide the experiment by the first 32 trials and the last 32 trials. Because the control and experimental trials were intermixed, this first half of trials would vary in the proportion of experimental and control trials (e.g., 12 experimental and 20 control trials). To have equal number of experimental/control trials, we used the first 16 experimental/control trials and last 16 experimental/control trials.

and there was a main effect of Half, $p < .001$: participants reported the critical region as figure more in the second half of trials than the first half for all conditions. Interestingly, there was a marginal interaction between Trial Type (experimental vs. control) and Half (first vs. second), p = 08. Although this interaction was not statistically significant, there was a possible difference emerging between experimental and control trials in the second half of trials in the DO-SC condition—a relevant difference that could explain the presence of this marginal interaction.

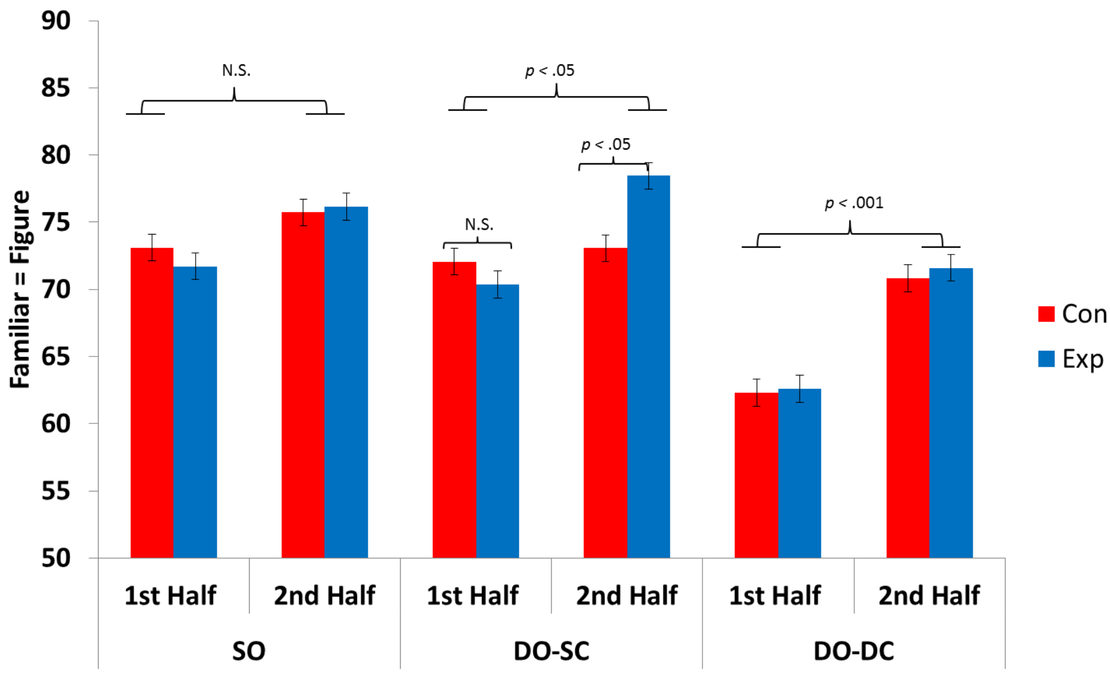


Figure 9

Figure 9. The data from Experiment 1binned into halves and separated by condition. Plotted on the x-axis is the first and second half of trials and priming condition (SO, DO-SC, and DO-DC). The y-axis represents the likelihood of perceiving the critical region as the figure. The blue bars represent the data from experimental trials, while the red bars represent control trials.

To explore how learning might affect performance in each priming condition differently, we conducted three ANOVAs with within-subjects factors of Trial Type (experimental vs. control) and Half (first vs. second). For the SO condition, there were no main effects or interactions, F's < 2.16 *ps* > .14. Thus, either the prime did not affect figure assignment or the participants adopted a strategy early on to respond to the early-arriving shape or semantic information arriving from the displays on both experimental and control prime trials. For the DO-SC condition, there was a main effect of Half, $F(1, 28) = 5.99$, $p = .02$, and an interaction between Trial Type and Half, $F(1, 28) = 4.61$, $p = .04$. This interaction was further investigated by paired t-tests that compared the difference between experimental and control trials at the first and second half. Critical region as figure reports were larger on the experimental than control trials during the second half of the experiment, $t(28) = 2.59$, $p = .02$, but not during the first half, $t(28) = .842$, $p = .41$ Thus, in the DO-SC condition, we observed traditional priming effects in the second half of the experiment: the activation of the superordinate category information (natural/artificial) from the real word primes on experimental trials increased the probability that the critical region was the figure relative to non-word control primes. Finally, for the DO-DC condition, there was a main effect of Half, $F(1, 32) = 15.19$, $p < .001$, but no effect of prime type and not interaction, *p*s > .79.: critical region as figure reports increased in the second half of the experiment on both experimental and control trials. Thus, this pattern of results suggests that the presence of DO-DC primes intermixed with control primes adversely affected figure assignment during the first half of trials but this effect was temporary and is overcome in the second half trials.

Experiment 1 Discussion

Although we did not observe traditional priming effects when we looked at condition means —experimental trials were equal to control trials—Experiment 1 showed that the primes were effective in that the critical regions were perceived as figures more often in the same category conditions (SO and DO-SC) than in the different category condition (DO-DC). We call this outcome the *Prime Context Effect* because the probability that the critical region was perceived as the figure was affected by the context of the priming condition. The context must have been established by the real word primes shown on experimental trials and then extended to control trials because the same non-word primes were shown on control trials in all conditions.

The context of each condition in the experiment offers a plausible explanation why there was no difference between control and experimental trials within a condition. For the same category conditions (SO & DO-SC), the prime and familiar configuration activated the same semantics either at a basic level in the SO condition or at a superordinate level (natural or artificial) in the DO-SC condition on 50% of the trials; these were the experimental trials. Conversely, for the different category condition (DO-DC), the semantics of the prime mismatched that of the familiar configuration at both a basic level and a superordinate level on 50% of the trials. Superordinate categorical information may be important for perceptual processing. Superordinate categorical information may be processed faster than basic and subordinate level information (Macé, Joubert, Nespoulous, & Fabre-Thorpe, 2009; Mohan & Arun, 2012). Thus, it may be more efficient for the visual system to prioritize superordinate categorical information, such as categorizing a fast approaching object as an animal rather than trying to categorize the animal at a basic categorical level (e.g., lion or tiger). Perhaps the percentage of experimental prime trials (50%) was sufficient for participants to implicitly learn the matching versus mismatching relationship between the semantics of the prime and the target. (We assume the learning was implicit because the prime was both forward and backward masked.) As a consequence of this implicit learning, the weight assigned to semantics in determining figure assignment may have been altered. This change in weight would have affected control trials as well as experimental trails, even though on control trials semantic information came only from the critical region in the display

To explore whether the prime differentially affected figure assignment throughout the experiment, we conducted a half analysis. Implicit learning differed across the three priming conditions. In the SO condition, critical region as figure reports remained constant (~75%) throughout the experiment. We observed no evidence of priming or learning. However, it is possible no evidence of priming was observed because participants' critical region as figure reports were at a functional ceiling, which obscured any evidence of facilitation or learning.

In the DO-SC condition, we observed a traditional semantic priming effect in the second half of trials: the critical regions were perceived as figure more often on experimental (real word) than control (non-word) prime trials. (Semantic priming was not evident in the first half of trials in the DO-SC condition: the critical region was perceived as figure approximately equally often on experimental (real word) and control (non-word) trials.) The DO-SC condition affords the best test of whether semantics per se affect figure assignment because the prime names an object with a different shape but the same category as the object depicted by the critical region in the bipartite display. It seems that participants implicitly learned to use the superordinate categorical information and to ignore the basic category (i.e., shape) information in the prime. Hence, by looking beyond the means and examining performance changes across trials, we were able to demonstrate that semantic priming can affect figure assignment.

In the DO-DC condition, real word primes temporarily reduced the probability the familiar configuration was the figure in the first half of the experiment, but familiar region as figure reports returned to baseline performance in the second half. Because there was no difference between real and non-word primes in the DO-DC condition, this combination of real and non-words must have adversely affected figure assignment during the first half of trials, but this effect was temporary and was overcome in the second half trials.

Taken together, these results allow us to hypothesize about the mechanism for the *Prime Context Effect*. The context of the experiment sets the probability that the critical region will be perceived as the figure by changing the weight assigned in figure assignment to the semantic activation originating from the familiar configuration in the bipartite test display. Real words presented on experimental trials condition establish this context. On 50% of the trials, the prime is either semantically related or unrelated to the superordinate category (natural/artificial) of the familiar configuration in the test display. For the other half of the trials, the control (non-words) trials are strongly influenced by the priming condition because the weight assigned to the semantic activation originating from the familiar configuration is adjusted by the context. The relationship between the semantics of the prime and that of the critical region in the target display is implicitly learned throughout the experiment; consequently, the prime's influence changes over the course of the experiment. During the first half of trials, primes can lower the probability the critical region is the figure if they mismatch the superordinate semantics (natural/artificial category) of the familiar configuration and familiarity effects on figure assignment can be temporarily disrupted (DO-DC condition). Conflicting information from the prime is ultimately ignored in the second half of trials. Conversely, during the second half of trials, primes can increase the probability the critical region is the figure if they match the natural/artificial category of the familiar configuration (DO-SC condition); in the presence of matching primes, the weight given to semantics accessed by the familiar region early in time is increased.

The prime effect observed in this experiment is best understood by considering the main task of the experiment. The goal of the participant is to determine which side of the display appears to be the figure. It is beneficial to the participant to use the familiar configuration cue because on every trial portions of well-known objects are suggested on one side of the border of the test display. Participants learn to ignore semantic information that interferes with using this cue (DO-DC condition) and to use superordinate semantic information that enhances this cue (DO-SC condition).

Experiment 1 does not provide unequivocal evidence that the semantic activation of primes affects figure assignment, however. There are two major limitations: (1) between-group differences in the extent to which participants use the familiar configuration cue, rather than the *Prime Context Effects*, may affect the probability that the critical region is perceived as the figure and (2) of the lack of priming and learning in the SO condition is puzzling. These limitations are addressed below.

Because there is likely to be individual variation in using the familiar configuration cue, group differences can obscure the data. For example, by chance participants in the DO-DC group may not rely on the semantics of the familiar configuration as heavily as participants in the other two groups. That is, between groups differences may be due to differences between the participants in the different groups rather than to the priming condition. To establish that participants in all groups are using object memories during figure assignment, in Experiment 2, we included both upright and inverted displays. Peterson and colleagues showed that familiar configuration effects were obtained only when the critical region was upright and when the parts of the familiar configuration were arranged in their proper spatial relationship (Gibson & Peterson, 1994; Peterson, Harvey & Weidenbacher, 1991; Peterson & Gibson, 1994a & 1994b) because there is no delayed access to object memories (for review, see Peterson & Cacciamani, 2013). Therefore, inverting the displays will preserve all other figural cues but will delay access to object memories. If a group of participants is using familiarity during figure assignment, critical region as figure reports should be larger in upright than inverted displays.

As stated earlier, the reports of the familiar configuration as figure were equivalent in the SO and DO-SC conditions for both experimental and control trials when all trials were averaged. When performance in the experiment was examined more closely, a traditional semantic priming effect was evident in the DO-SC condition in the second half of trials, but not in the SO condition. The primes in both the SO and the DO-SC conditions are expected to activate the same coarse semantics of the familiar configuration; the prime in the SO condition activates the specific semantics of the familiar configuration as well. Therefore, we expected to see traditional semantic priming effects in the SO condition, yet we observed no more reports of the familiar configuration as figure on experimental trials than control trials. It is possible we did not observe any differences as a function of trial type in the SO condition because the critical region as figure reports were already at a functional ceiling (~75%). This can be alleviated by reducing the exposure duration of the bipartite test displays from 90 ms to 80 ms. Although the probability that the familiar configuration is the figure is likely to be reduced for all priming conditions when the exposure duration of the test display is reduced, priming differences between conditions should be retained (e.g., SO & DO-SC > DO-DC). Importantly, this manipulation should allow us to better test whether perceiving the familiar configuration as the figure can be enhanced by the prior presentation of the name of the object depicted by the critical region in the SO condition.

Experiment 2

In Experiment 2, we modified the design of the experiment to assess whether participants in all groups were using the familiarity cue during figure assignment by including inverted displays in order to determine if the group of participants in all priming conditions (e.g., DO-DC) was using the familiar configuration cue during figure assignment. Object memories are accessed sufficiently early to influence figure assignment when the familiar configuration is in its upright orientation but not when it is inverted. Consequently, when the familiar configuration in the bipartite display is upright rather than inverted, the critical region is more likely to be perceived as the figure (Gibson & Peterson, 1994; Peterson, Harvey & Weidenbacher, 1991; Peterson & Gibson, 1994a & 1994b). For example, through experience, the visual system has become accustomed to seeing people upright rather than upside-down (inverted). Therefore, if the orientation effect is absent for a particular group, these participants would be classified as not likely to be using the familiar configuration cue during figure assignment.

Another modification in Experiment 2 was that we used a block design to control for stimulus repetition between the first and second half of trials (this is discussed in more detail in the procedure section). In Experiment 1, the presentation of stimuli was intermixed; that is, some participants may have been presented the same images with a short time lag, others with a long time lag. The blocked design controls for this limitation. Finally, we also aimed to replicate the key findings of Experiment 1. Doing so would strengthen our claims that (1) participants learn the relationship between the semantics associated with the experimental primes and the critical region in the bipartite test displays, and (2) that semantic activation can affect figure assignment.

Experiment 2 Design

Experiment 2 used a blocked design and included inverted figure-ground displays. The between-subjects factor was the priming condition (SO, DO-SC, & DO-DC) and the within-subjects factors were Orientation (Upright vs. Inverted), Half (first vs. second), and Trial Type (experimental/ real word & control/non-words). As in Experiment 1, the control and experimental trials were intermixed. The design is described in more detail below.

Stimuli

The stimuli were the same as those used in Experiment 1. All stimuli were presented in both an upright and an inverted (rotated in the picture plane by 180°) orientation. As in Experiment 1, the color and right/left side of the central border of the critical region were balanced.

Procedure

The instructions and practice trials were the same in Experiment 2 except for the presentation of the stimuli. The stimuli were blocked into two halves (similar to Experiment 1), and there were two hidden blocks within each half. For the first half, all the stimuli (32) were first presented in block 1. These 32 stimuli were assigned to four trial types (8 experimental-prime trials with upright displays, 8 control-prime trials with upright displays, 8 experimental-prime trials with inverted displays, and 8 control-prime trials with inverted displays). Experimental and control trials were intermixed within each block. After block 1, the same stimuli were presented again except the orientation of the stimuli was reversed: the set of stimuli inverted in block 1 were upright in block 2 and vice-versa. After the first half of trials, participants were asked to take a 2-minute break to relax and refocus on the task. For the second half, the sequence was the same except that trial type (experimental prime or control prime) were reversed: stimuli that were preceded by a real-word in the first half were preceded by non-words in the second half and vice-versa. In total, participants completed 128 trials (the 32 stimuli were repeated 4 times; 2X upright, and 2X inverted). Experiment 2 first and second half of trials are similar to Experiment 1 in that the first half contained the first 16 experimental/control trials for upright displays.

Finally, the exposure duration of the display was changed from 90 ms to 80 ms. Reducing the exposure duration was expected to lower the overall probability the critical region is the figure across all priming conditions but maintain difference (SO & DO-SC > DO-DC) among the three groups.

Prediction

We predicted that there would be an orientation effect. That is, the region suggesting a portion of a familiar configuration should be perceived as figure more often when it is depicted in its upright orientation than an inverted orientation. This pattern should be equivalent in the three groups if the participants in the three groups rely on familiar configuration as a figure cue approximately equally. Orientation effects are important because it would suggest that participants are accessing and using object memories during figure assignment.

We expected to replicate the *Prime Context Effect* in Experiment 2. That is, participants in the same category conditions (SO & DO-SC) should report perceiving the critical region as figure more often than participants in the different category condition (DO-DC). We also predicted differences in the first and second half of trials. For the SO and DO-SC conditions, in the first half, we expected that no semantic priming would be observed (i.e., critical region as figure reports would be equal on experimental and control prime trials), but, in the second half, we expected to observe semantic priming (i.e., critical region as figure reports would be greater for experimental than control trials). Conversely, for the DO-DC condition, we predicted that critical region as figure reports would be lower during the first half and higher in the second half, irrespective of prime trial type (experimental/control), as in Experiment 1.

Participants

One hundred thirteen participants took part in Experiment 2; of those, 81 were included in the final analysis: 26 in the SO condition, 28 in the DO-SC condition, and 27 in the DO-DC condition. The data from 32 participants were excluded: nine participants did not meet the response criterion, one participant was removed for being too ill; two participants were eliminated because of not following instructions, six participants were removed from the analysis because they were aware of the word prime; and finally, 14 outliers were removed because their responses deviated from their condition mean by more than two standard deviations

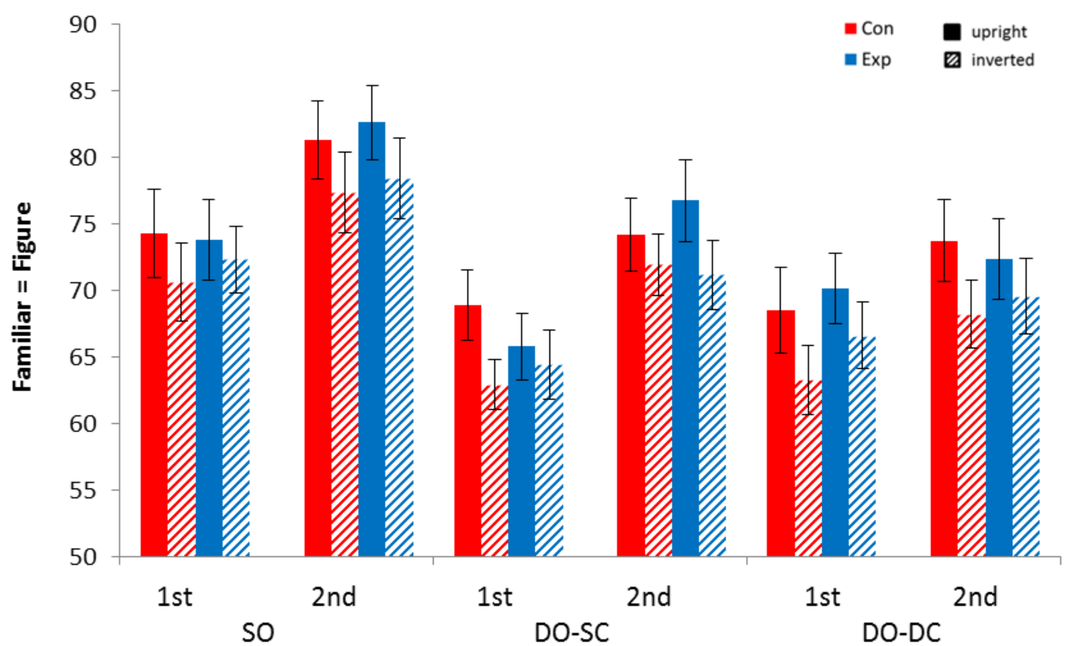


Figure 10

Figure 10. The data from Experiment 2. The y-axis represents the likelihood of perceiving the critical region as the figure. The x-axis represents the three conditions(SO, DO-SC, and DO-DC) and first and second half. Sold colored bars represent the data from upright displays, while striped bars represent inverted displays. The color of the bars represents trial type: blue = experimental and red = control.

Experiment 2 Results

An ANOVA was conducted on the percentage of familiar region as figure reports with a within-subject factor of Trial Type (experimental vs. control prime), Orientation (upright vs. inverted), Half (first vs. second half), and a between-subjects factor of Priming Condition (SO, DO-SC, & DO-DC). There were main effects of Priming Condition, $F(2, 78) = 3.52$, $p = .034$ (SO =76%; DO-SC = 70%; DO-DC = 65%) and Orientation, $F(1, 78) = 25.80$, $p > .001$ (Upright = 74%; Inverted = 70%). Importantly, there was a main effect of Orientation, $F(1, 78) = 26.01$, p < .001, and Orientation did not interact with other variables, ps > .30. Thus, participants in all groups were using the familiarity cue during figure assignment because the familiar configuration was seen as the figure more often when the displays were upright (74%) than inverted (70%). There was a main effect of Half, $F(1,78) = 33.97$, $p < .001$, with more critical region as figure reports in the second half (75%) than the first half (69%). Half did not interact with any other variables, however. Importantly, there was a main effect of Orientation, $F(1, 78) = 26.01$, p < .001, and Orientation did not interact with other variables, ps > .30. Thus, participants in all groups were using the familiarity cue during figure assignment because the familiar configuration was seen as the figure more often when the displays were upright (74%) than inverted (70%). As can be seen Figure 10, there was a main effect of Priming Condition, $F(2,78) = 3.50$, $p = .035$. Participants were more likely to perceive the critical regions as figures in the SO condition (76%) than in either the DO-SC or the DO-DC conditions (70% and 69%, respectively)**,** which is a partial replication of the *Prime Context Effect* observed in Experiment 1, although the pattern is somewhat different. In addition, there was a main effect of Half, $F(1,78) = 33.97$, $p < .001$, with more critical region as figure reports in the second half (75%) than the first half (69%). Half did not interact with any other variables, however. The half effect is shown in Figure 11 for upright displays.

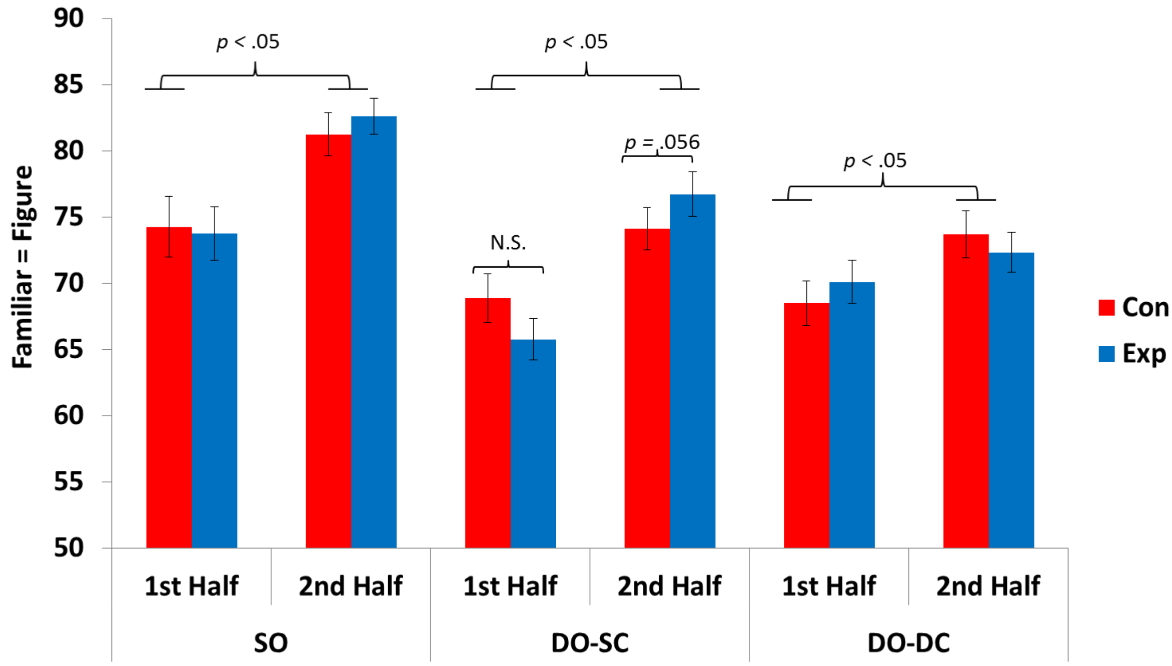


Figure 11

Figure 11.The data from Experiment 2 (upright trials only) separated by condition. The y-axis represents the likelihood of perceiving the critical region as the figure. Plotted on the x-axis is the priming condition (SO, DO-SC, & DO-DC) and the first and second half of trials. The color of the bars represents trial type: blue = experimental and red = control.

To explore how the prime affects each priming condition differently in the first versus second half of the experiment, we conducted three ANOVAs with within-subjects factors of Trial Type (experimental vs. control prime), Orientation (upright vs. inverted) and Half (first vs. second). For the SO condition, we observed main effects of Orientation, $F(1, 25) = 5.25$, $p = .03$, and Half, $F(1, 25) = 12.35$, $p = .002$ (See Figure 11 for effect of half). There was no effect of prime type, $F(1, 25) = .50$, $p = .49$ and no interactions, all F's < .214, *ps* > .64. Thus, participants in the SO condition used object memories during figure assignment and perceived the familiar configuration as the figure more often during the second half of trials; moreover, the prime type (experimental/control) had no observable effect on the figure assignment within the SO condition.

For DO-SC condition, we also observed main effects of Orientation, $F(1, 27) = 8.95$, $p = .006$, and Half, $F(1, 27) = 14.70$, $p = .001$. Interestingly, there was also a 3-way interaction of Trial Type (experimental vs. control) x Orientation (upright vs. inverted) x Half (first vs. second), $F(1, 27) = 4.93$ $p = .035$. This interaction was further investigated with paired t-tests that compared Trial Type (experimental vs. control) and Orientation (upright vs. inverted). For Trial Type comparisons, participants were (marginally) more likely to report the critical region as the figure on experimental than control trials, $t(27) = 1.97$, $p = .\ 057$ for upright trials only; all other comparisons failed to reach statistical significance, $ps > .14$ The experimental vs. control prime difference observed on upright trials is the same semantic priming effect observed in Experiment 1: semantic activation from the real word (experimental) primes affected the probability the critical region was the figure relative to non-word primes during the second half of the experiment. For the Orientation comparisons, participants were more likely to perceive the critical region as figure with upright displays than inverted displays on control-prime trials in the first half and on experimental-prime trials in the second half, $ps < .05$.

In the DO-DC condition, there was a main effect of Orientation, $F(1, 26) = 13.75$, $p = .001$, and Half, $F(1, 26) = .7.06$, $p = .013$. These data suggest participants in the DO-DC condition were using the familiar configuration cue during figure assignment and were more likely to perceive the familiar configuration as the figure during the second half of trials, replicating Experiment 1; moreover, the prime type (experimental/control) had no observable effect on the figure assignment within this condition.

Experiment 2 Discussion

We replicated the *Prime Context Effect* in Experiment 2 in mean performance: Participants perceived the familiar configuration as the figure significantly more in the SO condition than in the DO-SC and DO-DC conditions. Yet the pattern was different from the *Prime Context Effect* observed in Experiment 1 (SO & DO-SC > DO-DC). As with Experiment 1, in the overall analysis, experimental and control trials did not differ. The real word prime trials established a context that influenced performance on the non-word prime trials. Exploring each condition separately, we found that participants were more likely to perceive the familiar configuration as the figure with additional trials. Interestingly, the pattern observed in the DO-SC condition in Experiment 2 was similar to the pattern observed in Experiment 1: the critical region was perceived as the figure more often on experimental-prime trials than control-prime trials in the second half for upright displays only. We observed some evidence of traditional semantic priming for the DO-SC condition if this condition is analyzed separately. However, because there was no three-way interaction with Prime Condition, Trial Type, and Half in the overall ANOVA, we do not have unequivocal evidence of traditional semantic priming. Nevertheless, it is possible the participants in the DO-SC condition learned to use the semantic activation shared by the prime and the critical region of the bipartite test display (superordinate categorical information related to natural/artificial categories) and disregard specific object information from the real word primes. Moreover, this semantic priming effect was only present when the displays were upright and in the second half of trials, which suggests that this strategy is learned and is only applicable if the semantic network is activated by upright displays at test.

There were two notable inconsistencies across the two experiments: (1) the *Prime Context Effect* was different between the two experiments (Exp. 1: (SO & DO-SC > DO-DC; Exp. 2: (SO > DO-SC & DO-DC) and (2) DO-DC priming were not equivalent in Experiments 1 and 2 . Methodological differences between Experiment 1 and 2 might explain these inconsistencies: the display exposure duration, the number of trials, and the orientation manipulation (upright/inverted).

The exposure duration of the target display was different for Experiment 1 and 2, (90 ms & 80 ms, respectively). The main purpose of reducing the exposure duration in Experiment 2 was to reduce a possible functional ceiling effect in Experiment 1that may have prevented the observation of larger priming effects in the SO condition than the DO-SC condition. This manipulation could explain why DO-SC and DO-DC were equivalent in Experiment 2. An 80-ms exposure duration may not have been enough time for the coarse semantics of the word prime to be integrated with the coarse semantics of the familiar configuration. In the DO-SC condition, the prime is related to the critical region in the display only by superordinate category membership (natural/artificial), which may require the exposure duration of the target display to be longer (90 ms). Conversely, SO primes are related to both the basic and superordinate category of the familiar configuration, which may not require the exposure duration of the target to be as long. Another difference between the two experiments is the number of trials. Although Experiments 1 and 2 had the same number of trials with DO-DC experimental primes with upright displays (32), they differed in the number of total trials (Exp. 1 = 64; Exp. 2

= 128) and display type (Exp. 1= upright displays only, Exp. 2 = upright and inverted displays). These differences might also contribute to changing the probability that the critical is the figure.

Although both experiments established that semantic activation of masked primes affected figure assignment of the familiar configurations, we do not know what baseline performance is. Without an adequate baseline, it is impossible to know the degree of influence the word prime has on figure assignment. Thus, an experiment that includes a control condition in which no word primes appear is required to further elucidate how semantic activation affects figure assignment. As demonstrated in Experiments 1 and 2, performance on non-word prime trials was strongly affected by the presence and type of real-word primes. If non-word primes are present without real-word primes, critical region as figure reports will provide an estimate of the baseline performance because non-words are theorized not to systematically activate the semantic network as strongly as real words (e.g., Binder et al., 2003). In Experiment 3, we tested a new group of naïve participants who did not take part in the previous experiments. The design of Experiment 3 was similar to Experiment 2 with the exception there were no real word primes.

Experiment 3

Participants

Thirty-two participants took part in Experiment 3. The data from three participants were removed for the analysis: one was older than 23, one was an outlier, and one was aware of the word prime. Consequently, the data from 29 participants were entered into the analysis.

Design

The design of Experiment 3 is similar to Experiment 2 (exposure duration and blocking), but there was only one trial type (non-words).

Experiment 3 Results

An ANOVA was conducted on the percentage of critical region as figure reports with within-subject factors of Orientation (upright vs. inverted), and Half (first vs. second). There was no effect of Half, $F(1, 28) = 1.06$, $p = 311$. The only variable to reach statistical significance was Orientation, $F(1, 28) = 15.21$, $p = .001$. Participants reported perceiving the critical region as the figure more often in upright displays (70%) than inverted displays (65%). These results confirmed our estimate of baseline reports of the familiar region as figure for upright trials (70%), and showed that familiar region as figure reports did not increase with experience in when only non-word primes are used.

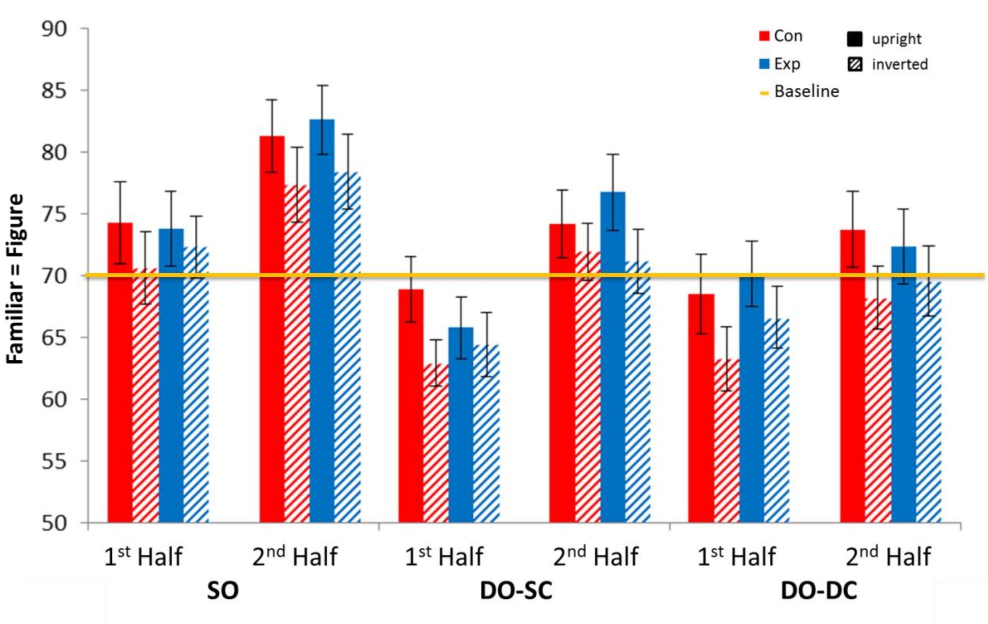


Figure 12

Figure 12. The data from Experiment 2 and 3.The orange line represents baseline performance from Experiment 3 (70%). The y-axis represents the likelihood of perceiving the critical region as the figure. Plotted on the x-axis are the three priming conditions (SO, DO-SC, & DO-DC) and the first and second half. Sold colored bars represent the data from upright display, while striped bars represent inverted display.

We also compared performance in Experiment 3 with performance on control-prime trials in Experiment 2, where the non-word primes are intermixed with real-word primes. We first conducted an ANOVA with a between-subjects factor of Priming Condition (SO, DO-SC, DO-DC, Con) and a within-subjects factor Orientation (upright vs. inverted) using only control trials. There were main effects of Orientation, $F(1, 106) = 31.61$, $p < .001$, and Priming Condition $F(1, 106) = 2.93$, $p = .037$. Orientation and Priming Condition did not interact $F(3, 106) = .24$, $p = .87$. Follow-up analyses revealed that participants in the SO condition (76%) perceived the critical region as figure significantly more often than the other priming conditions (DO-SC = 70%, DO-DC = 68%, and Con = 67%). Moreover, participants in the Control condition (Experiment 3) perceived the critical region as figure approximately equally often as participants in the

DO-SC and DO-DC conditions of Experiment 2. Hence, figure assignment in the DO-SC and DO-DC conditions was equivalent to figure assignment in the Control condition. Likewise, we obtained the similar results using only experimental trials except for the Control condition (Experiment 3): main effect of Orientation and participants in the SO condition perceived the critical region as figure significantly more than the other priming conditions

Experiment 3 Discussion

Experiment 3 was specifically designed to determine the baseline probability of perceiving the familiar configuration as figure when there were only non-word primes. These non-word primes do not systematically activate the semantic network, and therefore should not have an effect on figure assignment. Reports that the critical region was the figure in the control condition matched the estimate we derived from previous experiments (70%; e.g., Gibson & Peterson, 1994). We attribute these reports to access to object memories during figure assignment, because the orientation of the display affected the probability that participants reported perceiving critical regions as figures (upright > inverted). Interestingly, the half analysis revealed that more trials did not increase effects of the familiar configuration on figure assignment, which suggests that when there is no activation of the semantic system, performance does not change with more trials.

The results of Experiment 3 helped further elucidate the *Prime Context Effect* of Experiment 2 (SO > DO-SC and DO-DC). Based on the overall mean analysis, baseline activation performance was equal to performance in the DO-SC and DO-SC conditions. Therefore, in Experiment 2, the SO primes (real words and non-words) increased the probability the critical region was the figure. Participants in the SO condition may have implicitly adopted a different strategy. Because the real word primes name the object depicted by the critical region of the target display, the word activates object representations that are also activated by the critical region of the test display. Given this concordance, participants may learn to use early information regarding familiar configuration for figure assignment. The consequence of this strategy is that critical region as figure reports will be equivalent in experimental and control trials throughout the experiment.

General Discussion

The visual system can rapidly process the meaning of potential objects in a visual scene (Cacciamani, et al., under review; Peterson et al., 2012; Sanguinetti, Allen, & Peterson, 2014), but it was not known if semantic activation had a functional consequence for figure-ground perception. We ran three experiments that investigated whether priming the semantics of objects using a masked prime paradigm affected figure assignment in bipartite displays that had a portion of a familiar object suggested on one side of a central border separating two equal area black and white regions. The task was to report which side (left/right) of the display appeared to be the figure. We manipulated the semantic relationship between the word prime and the critical region in the target display (a familiar configuration in the bipartite display) with three priming conditions (SO, DO-SC, and DO-DC). In the SO condition, the word prime matched the basic and superordinate level category of the familiar configuration (e.g., dog-dog). In the DO-SC condition, the word prime matched the superordinate natural/artificial category of the familiar configuration but named a different object (e.g., arm-dog). In the DO-DC condition, the word prime did not match the superordinate natural/artificial category of the familiar configuration and named a different object (e.g., car-dog). In addition, we included non-word primes to allow baseline performance comparisons within each priming condition. Non-words were expected not to systematically activate the semantic network and therefore were not expected to affect figure assignment.

In Experiment 1, there were no differences between experimental and control trials—an essential difference that is traditionally used as evidence of priming—when averaging over all trials. However, we did observe an effect of priming condition: Participants perceived the critical region as figure more in the same category conditions (SO and DO-DC) than in the different category condition. We call this the *Prime Context Effect* because the overall context of the experiment affected the probability that the critical region was perceived as the figure. Real word primes establish the *Prime Context Effect* because the same non-words were used in each priming condition. The context of the experiment changed the weight of the semantic activation of the familiar configuration.

We also observed implicit learning across the priming conditions by comparing performance in the first and second half of the experiment . In the SO condition, critical region as figure reports remained constant throughout the experiment because participants were using a different strategy by attending more to the shape of the figure-ground displays instead of learning to use the semantic activation of the real word primes. In the DO-SC condition, we obtained a traditional semantic priming effect in the second half of trials: the critical regions were perceived as figure more often on experimental than control trials. (This effect was observed only when priming conditions are analyzed separately). Remarkably, these participants implicitly learned to use the superordinate category information that matched that of the critical region in the test displays rather than the specific shape of the object named by the prime. In the DO-DC condition, real word primes temporarily disrupted figure assignment during the first half of trials because the prime mismatched the critical region in both category (natural/artificial) and shape. However, in the second half of trials, participants learned to rely only the familiar configuration cue present in the test displays.

In Experiment 2, we included inverted displays to test if participants were using object memories (i.e., the familiarity configural cue) during figure assignment. We replicated the *Prime Context Effect*: participants reported the critical region as the figure more in SO than the DO-SC and DO-DC conditions. That is, we showed that the *Prime Context Effect* was not due to chance assignment of participants with a weak bias to use familiarity to the DO-DC condition: participants in all groups were more likely to report the critical region the figure when the displays were upright than inverted, an established marker that they used familiar configuration as a figural cue.

We also looked at the first and second half of trials in Experiment 2. Participants were more likely to report the familiar configuration as the figure during the second half of trials, regardless of priming condition. Thus, for all priming conditions, participants learned to rely more on the semantic activation from the target displays as the experiment progressed. To explore how each priming condition could differentially affect learning, we analyzed each priming condition separately. For the SO and DO-DC conditions, there were no differences between experiment and control trials at the first and second half of trials. For the DO-SC condition, however, we observed possible evidence of semantic priming: during the second half of trials, the familiar configuration was more likely to be perceived as the figure if the word prime was a real word than a non-word. Traditional evidence of semantic priming was observed in DO-SC condition by analyzing priming conditions separately. However, when an omnibus ANOVA was conducted, with Priming Condition as a factor, there was no three-way interaction involving Priming Condition, Prime-Type, and Half, which is an important interaction that would support traditional effects of semantic priming. Thus, a new set of experiments is needed that can better measure the contribution of semantic activation from the primes to figure assignment to test for traditional effects of semantic priming. One possibility is to include a task that requires more involvement of the semantic network to perform a given task, such as the task used by Peterson et al. (2012) where participants had to decide whether a word names a natural or artificial object. Experiments that include an explicit task that requires evaluating the semantics of objects may be better suited to test traditional semantic priming effects.

In Experiment 3, we tested a separate group of naïve participants in which the context only consisted of non-word primes to determine baseline performance. This control group was used as a baseline performance comparison to establish the magnitude of the priming effect of real word primes on figure assignment. These participants were using object memories during figure assignment, as indicated by an orientation effect (upright > inverted). Based on the overall means, the control group (Experiment 3) was equivalent to DO-SC and DO-DC (Experiment 2), which suggest the participants in the SO condition drove the *Prime Context Effect* in Experiment 2. Interestingly, we did not observe any differences between the first and second half of trials with a context of non-words. Conversely, with a context of real and non-words in Experiments 1 and 2, there were differences between the first and second half of trials, with critical region as figure reports larger during the second half of trials. These data further suggest that semantic activation from real word primes (regardless of priming condition) contribute to figure assignment via increasing the weight of the semantic activation of the target display. However, more experiments are needed to determine the relationship how real/ non-words can affect the probability the familiar configuration is the figure.

Taken together, these results suggest that the context of the experiment affects whether the visual system will use the semantic activation of the masked prime during figure assignment. An important aspect of the context is the main task of the participant. For the current set of experiments, the task was to determine which side of the display appears to be the figure. It is beneficial to the participant to use the familiar configuration cue because there are portions of well-known objects in every trial. It is possible that semantic information that interferes with this task is likely to be ignored, while semantic information that enhances this task can be utilized if there are enough trials for the participants to implicitly learn to use the prime activation. Similarly, it has been reported that participant's task-set and strategy affects the strength and direction of unconscious information processing (Milliken et al. 1998; for review, see van Gaal, de Lange, & Cohen, 2012). For example, Naccache, Blandin, & Dehaene (2002) found that focused attention could affect semantic priming of masked primes by manipulating the temporal cues of the target. Thus, if there is temporal uncertainty of the presentation of the target, Naccache et al. did not observe any semantic priming, even though their participants were unaware of the prime.

The *Prime Context Effect* is similar to the *List Composition Effects* reported in the lexical priming literature. Here, evidence of semantic priming is a larger difference in RTs between related prime versus unrelated prime (e.g. cat-dog) during a lexical decision task (determining whether the target lexical stimulus is a real word or non-word). A *List Composition Effect* occurs when the list of words used in the experiment produces a strategic adaptation to the task that can affect the behavior that measures semantic priming (Forster, Mohan, & Hector, 2003). For example, Bodner and Masson (2001) manipulated semantic priming by including repetition priming in the context of the experiment using a masked priming paradigm. With repetition priming, the primes and targets are the same words during a lexical decision task (e.g. dog-dog). Bodner and Masson proposed that including repetition priming on a majority of trials could make all primes in the experiment more valid. That is, participants will be more likely to use the semantic activation from the prime to determine if the target word was a real word or non-word. They used two groups of participants: high prime validity group (80 % of trials had repetition priming) and low prime validity group (20% of trials had repetition priming). Stronger priming effects were observed for participants in the high prime validity group than participants in the low prime validity group. Bodner and Masson concluded that during word recognition the semantic network is turned to the regularities of the experimental context, which is different from the classical assumption that there is an automatic spread of activation from the prime.

Likewise, participants in the current set of experiments may have adopted learning strategies based on the context of the experiment. There were learning effects in Experiments 1 and 2 when each priming condition was analyzed separately (although no learning in the SO condition for Experiment 1). These participants were more likely to perceive the familiar configuration as the figure during the second half of trials. To explore the possibility of different learning strategies from the three priming conditions, we analyzed each condition separately to increase statistical power to detect any differences. For the SO condition, participants learned to use the earliest available familiar configuration information arriving from the test display. For the DO-SC condition, participants learned to use the matching coarse (superordinate) category information from the prime and not the actual object from the prime. This semantic activation increased the probability that the familiar configuration would be perceived as the figure in the second half of the experiment. For the DO-DC condition, participants may have learned to down-weight the prime and up weight information coming from the familiar configuration, perhaps by restricting their attention to the time when the test display appeared (see Naccache, et al, 2002). An important caveat to consider with this interpretation is that these differences could be due to chance at this level of analysis. Nevertheless, semantic activation of the prime did affect figure assignment because of the *Prime Context Effects* and there was no evidence of learning if the context consisted of non-words. Thus, our experiments help demonstrate that vision is a dynamic process: semantic activation had a functional consequence on figure-ground perception.

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