From concept to percept: Priming the perception of ambiguous figures

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Abstract

The essential nature of ambiguous figures (i.e., figures that support one or the other of two possible interpretations) presents an ideal measurement context within which to distinguish "top-down" versus "bottom-up" processing effects as they might apply in everyday perceptual experiences. Previous research has employed features of ambiguous figures as primes and manipulated subjects' fixation point, supporting a bottom-up view of processing (e.g. Georgiades & Harris, 1997). However, conceptually related "figure-ground" studies have demonstrated powerful top-down effects, with familiar regions usually labelled as the figure (Vecera & Oreilly, 1998). Interactive processing models that are meant to arbitrate such inconsistent findings have been proposed (e.g. Peterson & Gibson, 1994), but as yet have not been tested using ambiguous line drawings. In this study, four ambiguous line drawings were preceded by word label primes that were either "consistent with", or semantically "neutral" with reference to each of the two alternate interpretations. The proportion of subjects' responses that coincided with the primed interpretation (relative to baseline) constituted the dependent variable. A significant overall word priming effect was observed on the interpretation of the ambiguous line drawings, providing evidence of carry-over processing effects between 'concepts' and 'percepts'. Implications and future directions are discussed.From concept to percept: Priming the perception of ambiguous figures

Multistable ambiguous or reversible figures are visual stimuli that possess at least two alternate and distinct interpretations. While amusing as classroom demonstrations, the study of these possesses the potential to reveal some of the underlying perceptual processes at work in any visual environment containing a degree of interpretive ambiguity. For instance, the perceptual processes that determine one's first interpretation of such an object might arguably operate in a very similar manner when confronted with ambiguity in our everyday 3D world.

Prototypical examples of ambiguous figures within contemporary psychology include the Necker cube and Rubin faces/vase figure (see Figures 1a & 1b). The former is a 3D wire cube, viewed from either the top or the bottom. The Rubin face/vase image, on the other hand, is a traditional example of a figure-ground assignment problem. While bilateral mirror symmetry such as in the case of figure/ground assignment dilemmas constitute an especially regular departure from randomness in our visual world (Baylis & Driver, 2001), it is this very regularity of figure-ground images have made them a convenient tool in the study of the interpretation of ambiguous figures, as they allow for an easy manipulation of variables. A third category of ambiguous or reversible figures which do not depend on symmetry or repetition are 2D line drawings of figures that might be construed in at least two different ways, leaving the perceiver to "decide" which picture he or she sees.

This defining feature of ambiguous figures presents them as ideal experimental simulations in which the interactive roles of pre-conscious or automatic factors might be separated from those of conscious or strategic efforts, taking us a step closer to understanding our everyday perceptual experiences.

Feature integration theory (Treisman & Gelade, 1980) postulates that the individual features of an image are detected early and automatically, while the integration of these features follows and requires conscious attention. Thus the interpretation of an ambiguous figure would hinge on the particular features being focused upon. Tsal and Kolbet (1985) investigated the role of attention in the interpretation of ambiguous figures. Using letters placed in the focal areas of either interpretation, they found that subjects responded faster when letters coincided with the focal area of their perceived interpretation. As well, reported interpretations showed a strong relationship with the placement of letters in the ambiguous figure. In further support of a “bottom-up” model, Ellis and Stark (1978) showed that subjects’ eye movements varied along with changing interpretations of reversible figures. In other words, a change in interpretation appeared to require a corresponding change in focal fixation.

Goolkasian (1987) had subjects report their interpretation of ambiguous figures while manipulating the fixation point of her subjects just prior to figure presentation. If subjects tended to report an interpretation consistent with the placement of their fixation point at the location of a ‘critical feature’ of a particular interpretation, this would have generated support for the bottom-up model. However, either interpretation of the ambiguous figures tended to be reported with equal probability, whether fixation points coincided with critical features or neutral areas. Yet, a later study (Goolkasian, 1991) found that the advance presentation of critical features of alternate interpretations did in fact influence subjects’ labelling of ambiguous figures, providing the size of the figure exceeded a critical angle. Thus in the earlier study, it is possible that the hypothesized results were not seen due to the small size of presented figures.

Georgiades and Harris (1997) employed a complementary approach by removing critical features from ambiguous figures and gauging their effect on subjects’ interpretations. As expected, the probability of a particular interpretation deviated away from 50% as specific critical features were removed, biasing perceptions towards the intact interpretation. Furthermore, ambiguity was reduced as proximity increased between fixation points and critical features, this effect being more powerful for larger figures than smaller ones. Presumably, smaller images facilitate global cue detection, while leaving less room for local cue fixation, and vice versa.

An alternate model for the perception of ambiguous figures assigns more weight to “top-down” influences. According to Neisser (1967), feature analysis is preceded by a stage wherein a hypothesis is generated about the nature of a stimulus based on the perceiver’s expectations. Thus context as well as content are presumed to play a role in interpretation (albeit not as equal partners). In line with this hypothesis, Bugelski and Alampay (1961) found that subjects tended to perceive the Rat/Man figure as consistent with preceding sketches of either humans or animals in approximately 75% of cases (see Figure 1c).

In another study (Goolkasian, 1987), subjects were briefly shown images either of critical features, neutral features, different features, or a biased interpretation of the entire figure before the actual ambiguous figure was presented. With some individual exceptions, only the advance presentation of a wholly biased image produced an overall effect towards the expected interpretation of the figure. This might also be taken as evidence of the differential interpretive ambiguity of multistable images. These results were also replicated using biased entire versions of two ambiguous figures (Jhangiani, 2003; see Figure 2).

Regions in an image which appear familiar, or that hold meaning for the perceiver, have been described as being highly denotative (Peterson, de Gelder, Rapcsak, Gerhardstein, & Bachoud-Lŭvi, 2000). Along with her colleagues, Peterson has shown that when subjects view figure-ground images that contain a highly denotative region, this is usually labeled as the figure, at least when the image is presented upright. However, when the very same images are rotated 180 degrees, this top-down effect is replaced with judgements based on symmetry and other Gestalt configural cues (cited in Vecera &

Oreilly, 1998). Peterson and Kim (2001) further suggested that, when cues strongly bias the labeling of figure status on one particular side of a contour, cue detection and subsequent object memory referencing are inhibited on the opposite side, which partly explains why figures can be identified when they are familiar, whereas grounds cannot (Peterson, in press).

In an attempt to reconcile the seeming contradictions between the bottom-up and top-down models of ambiguous figure interpretation, Peterson and Gibson (1994) proposed an interactive model of processing, which asserts two types of cues that influence figure-ground organisation: The first are the Gestalt stimulus cues that include symmetry, convexity, and area. The second are pre-figural object representations that operate prior to figure-ground assignment. These second type of cues are said to pass on outputs from both sides of figure-ground contours to an object recognition process. If either representation matches an object memory, this information influences the subsequent figure-ground assignment.

A fully interactive model proposed by Vecera and O'Reilly (1998), also tackles this seeming paradox of how "object representations [can] influence figure-ground organization if the very goal of figure-ground organization is to provide input to object representations" (p. 442). According to their model:

> partial results from figure-ground processing can be sent to subsequent object representations. The object representations, in turn, can send activation back to the figure-ground units, providing top-down input before a stable figure-ground percept has been established. By this account, object representations can be viewed as another type of constraint on figure-ground organization, much as area, symmetry, and convexity constrain which region is perceived as figure. (442)

While support has been generated for both bottom-up and top-down models, a definitive interactive account has yet to gain widespread acceptance. Part of the problem involves the lack of empirical evidence to support a generalization of figure-ground assignment findings to real world perceptual phenomena. To this end, an application of an interactive model of processing to the interpretation of ambiguous line drawings would bring the discussion one step closer. As well, while interpretations of ambiguous line drawings have been effectively manipulated with the use of primes consisting of intact or biased versions of those figures, top-down effects within this context possess very little real world utility. For instance, in the real world, we are much more likely to be thinking about concepts prior to encountering ambiguous stimuli. Thus, arguably, it would be far more valuable to replicate previous findings using word label and semantic priming, as an index of suggestibility in identification tasks. In particular, if word-priming effects can be generated on picture viewing (over and above simple response priming), strong evidence will be provided for the carry-over processing effects between 'concepts' and 'percepts.'

The present study investigates the effects of the advance presentation of a word label followed closely by an ambiguous line drawing. Specifically, it is hypothesized that the advance presentation of a consistent label (e.g. "plane," prior to the Bird/Plane figure) will bias subjects' responses in favour of the labeled interpretation. Moreover, a second condition, employing neutral labels (e.g. "tree," prior to the Bird/Plane figure) will reveal the relative effect of such a bias, over and above response priming effects and the differential competition associated with alternate interpretations, across select ambiguous figures.

If subjects' responses tend to show a bias towards either interpretation being primed (relative to baseline), this can be taken as evidence for top-down processing effects in the case of word-label primes. However, if subjects also tend to report the neutral word primes as their own interpretations, this would simply demonstrate a response priming effect, meaning that there was a tendency for subjects to simply read the labels without truly interpreting the ambiguous figure. Finally, if subjects' averaged interpretations remain the same for each figure, across different word label primes, this would show that the word label primes do not have any effect on their perceptions, indicating that the average response for each figure depend largely on the displayed figure itself.

Method

Subjects

The volunteer subjects were 16 male and female undergraduate and graduate students and staff at the University of British Columbia who had normal or corrected 20/20 vision.

Procedure

The software program Presentation (version 0.75) was used to present the stimuli, which allowed for precisely controlled time intervals. Each trial began with a fixation point presented to the subjects for one second, centered upon an otherwise blank computer screen. This was followed by a brief word prime lasting 100 milliseconds, which in turn was immediately followed by the presentation of an ambiguous figure for 500 milliseconds. Subjects were informed of the sequential procedure, and told that they would be required to label the ambiguous figure as quickly as possible after it appeared. They were further told that a distractor word would appear in between the fixation point and the figure, which they were to ignore.

Five ambiguous figures were used, namely Boring's Young/Old Woman (1930), Bird/Plane and Duck/Rabbit (Tsal & Kolbet, 1985), Rat/Man (Chastain & Burnham, 1975), and Woman/Man (Fisher, 1967; see Figures 1a-e). These particular figures were chosen on the basis of their relatively equiprobable dual interpretations. In addition, previous work by Goolkasian (1991), and Georgiades & Harris (1997) have evidenced priming effects using critical features or biased versions of these same figures. The word primes used in this study consisted of one-syllable labels that were either consistent with each anticipated interpretation of the figure or semantically neutral. For example, "OLD," "YOUNG," or "TREE" in the case of the Young/Old Woman figure.

Subjects were randomly assigned to one of 4 conditions, where they serially viewed one trial for each of the five figures. Counterbalancing accounted for the prior presentation of either a consistent or neutral label, and the order of figures presented was randomized. At the end of each trial, subjects were given a forced choice response task to select the 'best fit' to their interpretation from all three priming word labels used for that figure. The three choices appeared at the left, center, and right sides of the screen in counterbalanced order. Subjects' were asked to report out loud their chosen label, as soon as possible.

The mean distance of subjects from the computer screen was 50cm, and the sizes of the images were approximately 21cm. The inter-presentation interval was about 5 seconds, during which subjects' responses were noted, and the next trial was selected.

The dependent variable consisted of the proportion of subjects' responses that favoured either interpretation of the ambiguous figure presented in each trial.

Results

Pooling data from all figures, the consistent prime conditions effected a significant change in the desired direction, relative to subjects' baseline responses [t (15) = 2.30, p=.036], with an average raw effect size per person of 20.83% [.95CI (1.51, 40.16), $\hat{\Delta}$ = .58].

Looking at the effects for individual figures, the increase in proportion of subjects' responses for each consistent prime (relative to baseline) was noted. These results are graphed in Figure 3. The largest increases were witnessed for the "plane" interpretation of the Bird/Plane figure (62.5%), followed by 37.5% increases in the interpretations of "bird," "rabbit," and "duck," respectively.

Despite the low overall power of the study, the "plane" interpretation of the Bird/Plane figure was significantly influenced by advance presentation of a consistent word label prime [z = 1.91, p<.05, directional]. As well, s

lightly weaker effects were found with the "Duck" interpretation of the Rabbit/Duck figure [z = 1.36, p<.10, directional]. Figures 4-8 also demonstrate the differential interpretive ambiguity per ambiguous figure at baseline. For instance, no subjects chose the "man" interpretation of the Rat/Man figure. As well, the Old/Young Woman was the only figure with a .50 baseline rate.

It might be noted that no subjects reported the neutral labels during consistent trials. One subject exhibited response priming tendencies, reporting the neutral word prime as her interpretation of the ambiguous figure during two neutral trials. The only exception to this was the Bird/Plane figure, in which 4 out of the 8 subjects in the neutral prime condition reported the neutral prime as their interpretation. These results are discussed in the next section.

Discussion

Overall, evidence was found for a top-down processing effect of word primes in the interpretation of ambiguous figures. An increase in the proportion of assigned interpretations, relative to baseline, was observed for each of the figures (although not for each interpretation). However, the limitations of this study must temper the interpretation of these results. For instance, only four subjects viewed each consistent label trial, while 8 subjects in each case viewed the neutral prime trials. Thus, an individual raw effect size of 12.5% represents the data of only one subject. While this has been understood as representing the influence of the word primes, it might just as likely be the result of random variation.

Certain features of this study, however, also cause it to be a rather difficult test of the top-down hypothesis. For one, almost 90% of subjects later reported previous experience with most or all of the ambiguous stimuli presented. This might well explain the limited response priming effects observed in this study. For instance, a subject aware that a particular figure can be interpreted as a rabbit or duck would be much less likely to report "ball" as their interpretation. A sample with no previous exposure to these stimuli (with no accompanying stored knowledge of the dual interpretations or existing interpretive preference) might possibly be even more susceptible to word priming effects.

Other aspects of the experimental design that reduced the likelihood of significant findings included the low power of the study, and the differential interpretive preference allotted to each ambiguous figure during the neutral trials. For instance, 87.5% of the subjects in the Woman/Man figure's neutral priming condition tended to interpret the figure as "man," leaving very little room for a further increase in proportion during the consistent label trials.

Another of the limitations of the current study involved the neutral label employed for the Bird/Plane figure. A full 50% of subjects in the neutral prime condition reported the neutral prime itself as their interpretation. In an ordinary context these might all be understood as response priming effects. However, during debriefings it was noted that at least two of these subjects interpreted the figure as an amoeba-like object, hence leading to their choosing the neutral label "cell." Future work with this figure should therefore obviously involve a better selected neutral prime.

In another individual case, no subjects interpreted the Rat/Man figure as "man," whether in the neutral or consistent priming conditions. This is in contrast to Goolkasian's (1987) findings, where subjects reported "man" as their interpretation almost 50% of the time. Other than the small sample size or random variation, there is no good explanation at hand for this. In all other cases, as expected, it was shown that the different interpretations of different ambiguous figures are differentially likely to be reported.

Consistent with an interactive model of processing, subjects' responses during the neutral prime conditions reflect mostly bottom-up processing, with perhaps current state of mind or other top-down variables playing some role. However, the successful overall biasing effect observed is explained by the top-down processing effects of the consistent word primes. What is not clear of course is the order or exact interplay of these effects. While top-down effects might play a post-hoc role in the interpretation of incoming visual data, it is also possible that the (previously presented) word primes spurred the creation of a mental image of the prototypical object, which in turn organized the visual data as it arrived in the brain. Future work should employ the ambiguous figure paradigm to arrive at a definitive interactive model of processing.

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Figure Captions

Figure 1a. Necker Cube

Figure 1b. Rubin faces/vase figure

Figure 1c. Rat/man figure

Figure 2. Results from pilot study (pooled across single interpretation priming with two figures)

Figure 3. Percentage increases for each interpretation (individual raw effect sizes)

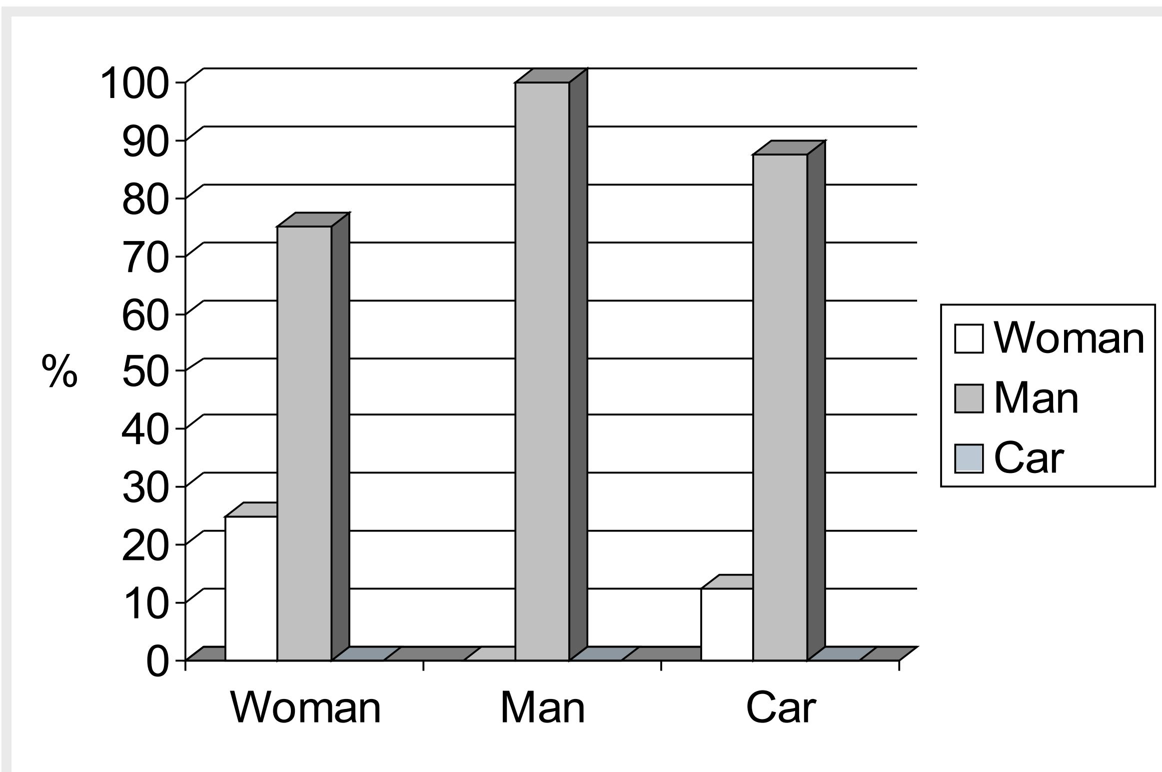
Figure 4. Results for Old/Young Woman figure

Figure 5. Results for Bird/Plane figure

Figure 6. Results for Duck/Rabbit figure

Figure 7. Results for Rat/Man figure

Figure 8. Results for Woman/Man figure



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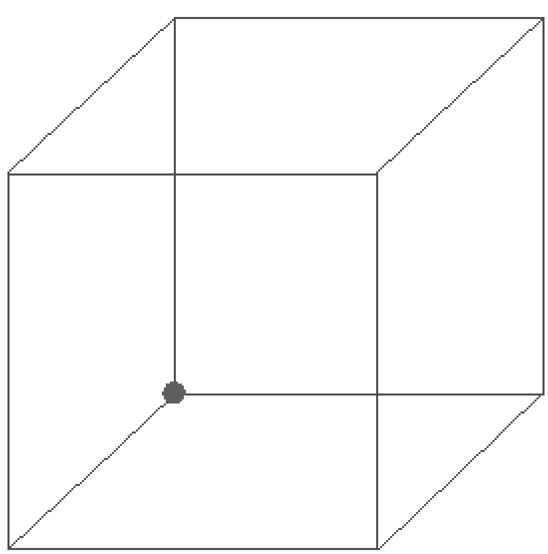

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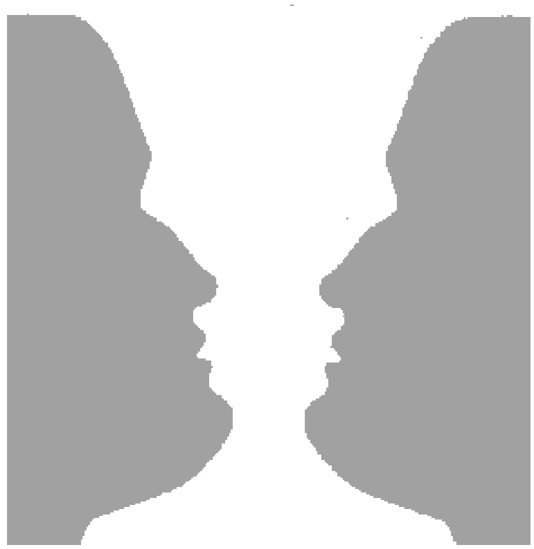

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Figure 2

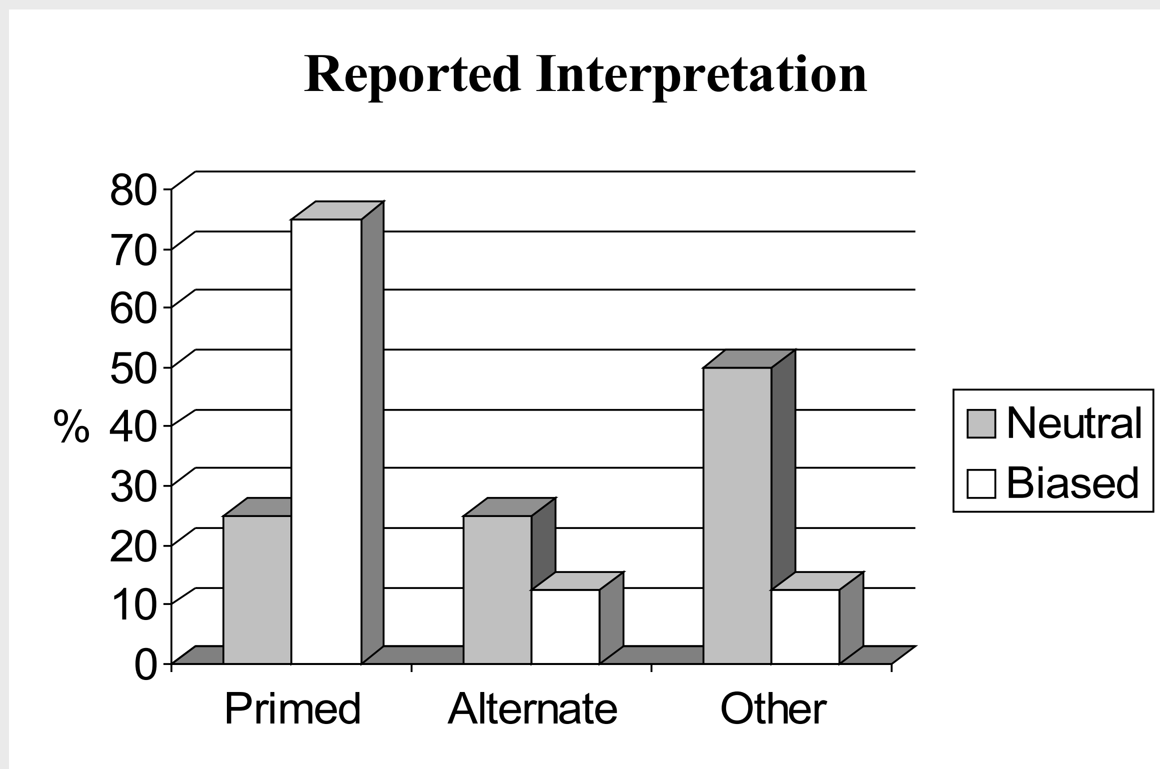

Figure 3

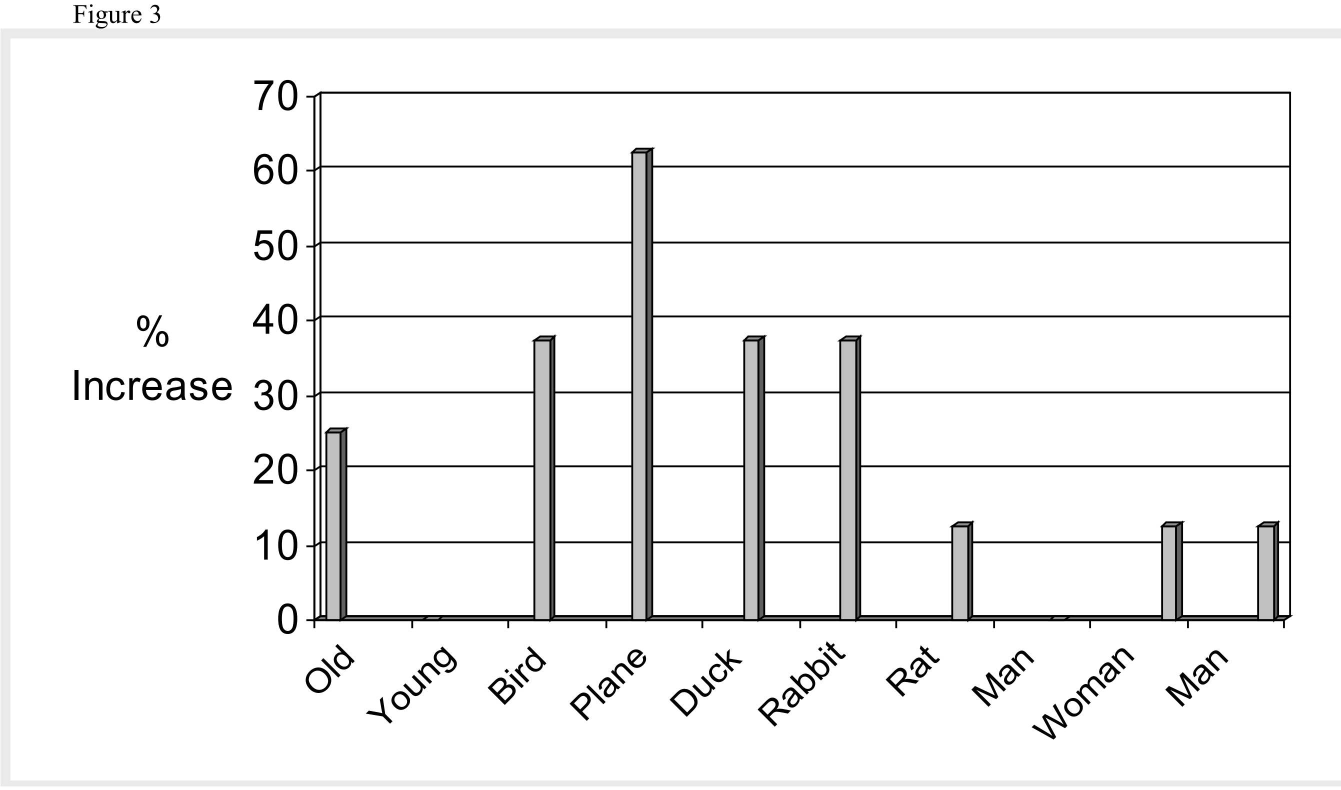

Figure 4

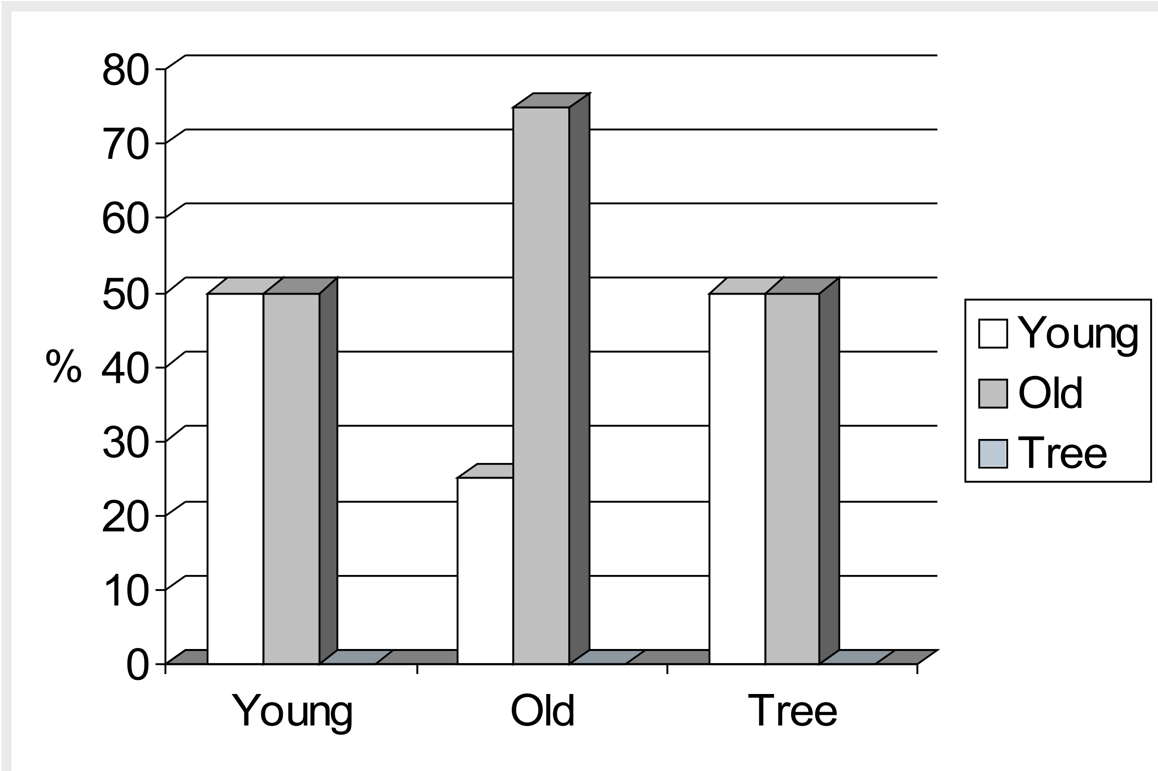

Figure 5

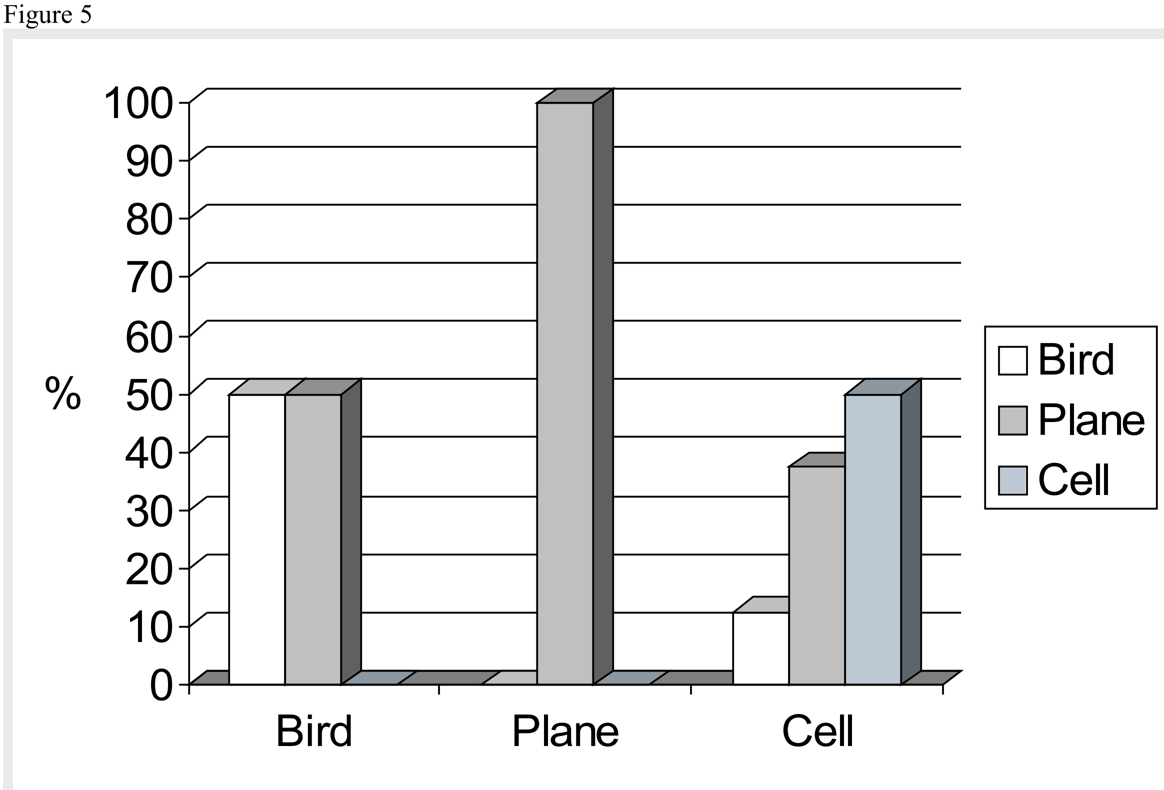

Figure 6

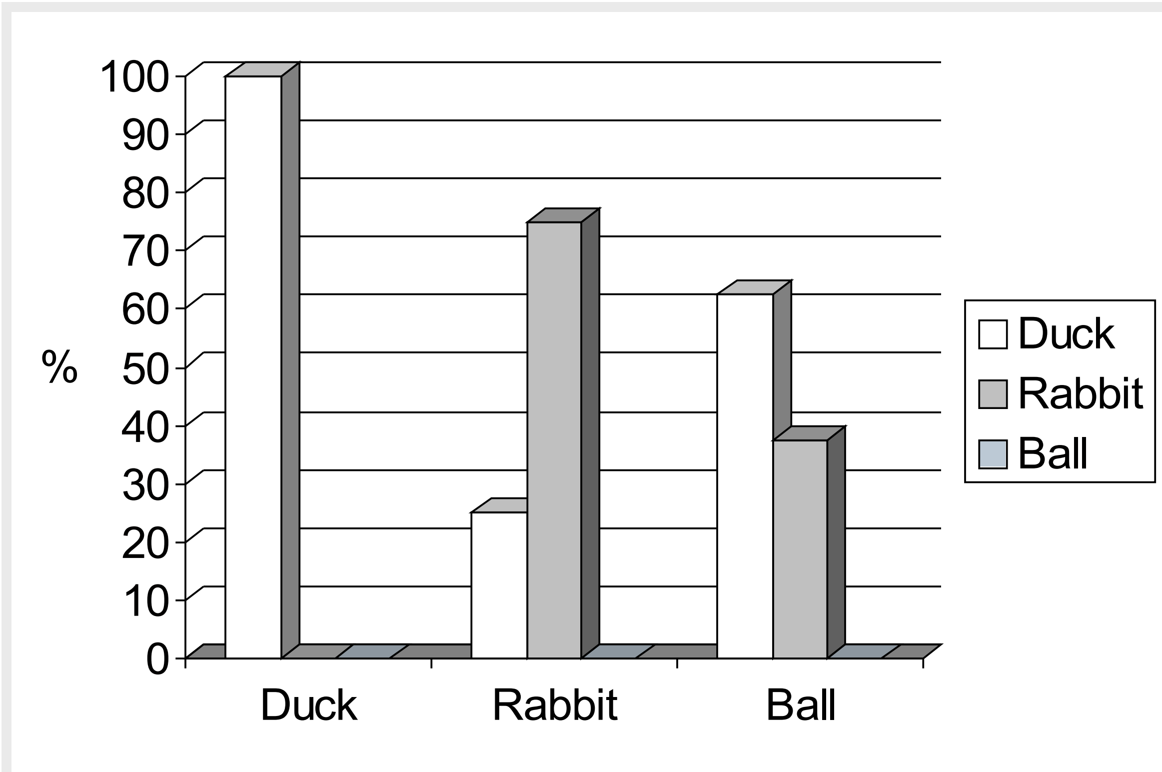

Figure 7

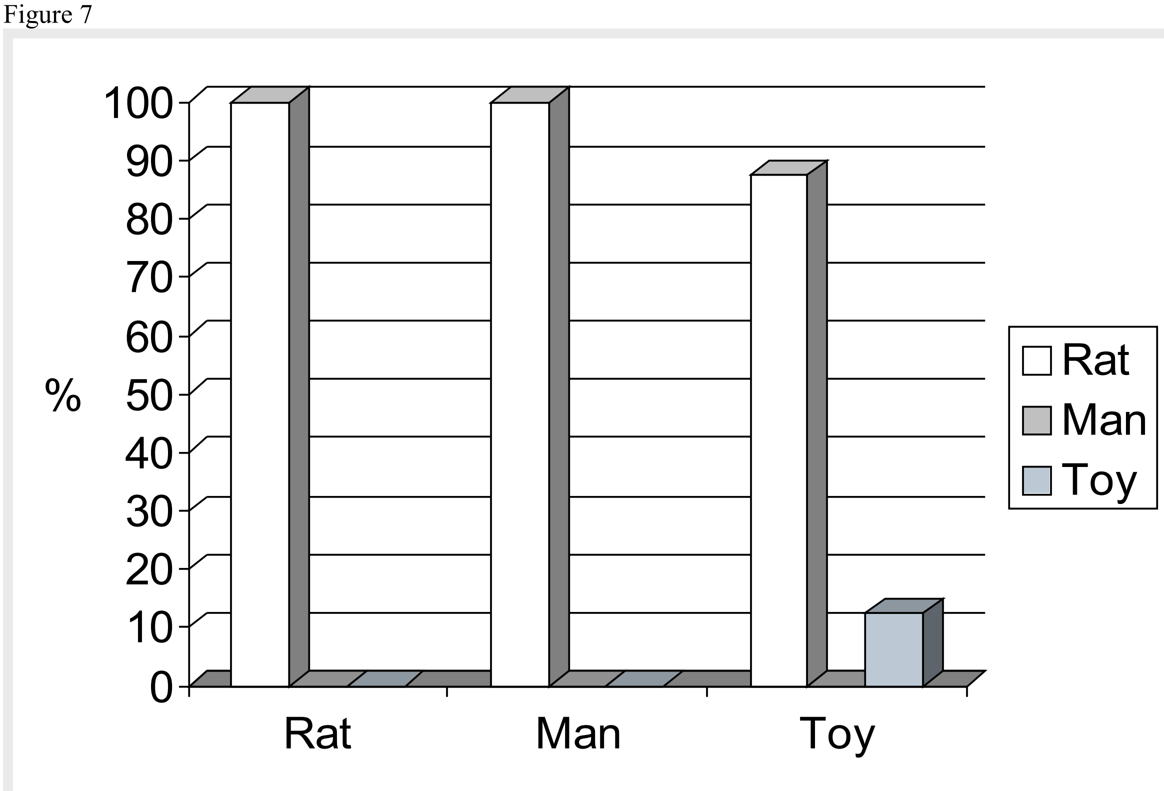

Figure 8