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## Effects of context of natural and artifactual objects on categorization

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Running head: EFFECTS OF CONTEXT ON OBJECT CATEGORIZATION

The Effects of Context of Natural  
and Artifactual Objects on Categorization

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### Abstract

Categorization of animals and vehicles in different contexts was investigated in three experiments using event related potentials (ERPs). The presence of a background and congruency of the background in relation to the object were both manipulated in order to determine the effects of context on visual processing. In Experiment 1, adults were presented with images of animals and vehicles in two conditions: situated in a congruent context (e.g. an animal in a field) and in the absence of a context (an animal in a white homogeneous background). In experiment 2, adults were presented with images of animals and vehicles in two conditions: situated a congruent context, and situated in an incongruent context (e.g. an animal in a parking lot). Experiment 3 served as a control, in order to test for effects of the images in the incongruent condition having been computer-graphically manipulated and therefore looking less natural than the images in the congruent condition. Latencies of N170, N250 and P300 components were analyzed in different brain regions. The findings show that processing of animals and vehicles is facilitated by the presence of a context and the congruency of the context.

## THE EFFECTS OF CONTEXT OF NATURAL AND ARTIFACTUAL OBJECTS ON CATEGORIZATION

Categorization is a vital skill for humans; the ability to classify objects helps us organize and understand our surroundings (Medin & Smith, 1981). Through the process of categorization, objects are grouped in order to establish and understand the relationships between different objects. In everyday interactions with the environment, humans categorize objects in a context; that is, the object and the surroundings of the object are visually processed in order to categorize the object. The present study focused on the influences of both the presence of a context and the congruency of the context on the facilitation of visual processing of an object.

It has been observed that different regions of the brain are engaged to different extents depending on the level of abstraction of the category (Tanaka et al., 1999). For example, subordinate categorizations, which are more specific than basic categories (e.g. desk chair) demand more visual resources to discriminate specific-level information, whereas superordinate categories, which group items according to functional purpose (e.g. furniture), occur at a later stage of processing because they are more general and therefore require more processing. In the present study, categorization at the superordinate level (animal or vehicle) is of interest.

Several types of neuroimaging methods have been used to study categorization. Functional magnetic resonance imaging (fMRI) technology generates images reflecting specific location of brain activation by observing blood flow changes. Positron emission tomography (PET) technology produces images representing the amount of brain activity in precise locations of the brain using radioactively labeled chemicals. Thus, these technologies are beneficial for observing precise locations of activation. Event related potential (ERP) technology has greater temporal resolution than fMRI and PET and allows for the investigation of rapid processing and categorization.

Many studies have examined categorization differences between images of animals and non-animals (Antal, Kéri, Kovács, Liszli, Janka & Benedekm 2001; Kincses, Chadaide, Varga, Antal & Paulus, 2006; Thorpe, Fize & Marlot, 1996; VanRullen & Thorpe, 2001). Thorpe et al. (1996) found using ERP technology that animal stimuli are more easily categorized than non-animal stimuli (including vehicles) in frontal regions. Another ERP study yielded similar results, with natural categories associated with shorter latencies than artifactual categories (Kiefer, 2005). From these results, it seems that natural stimuli are easier to categorize than artifactual stimuli. However, categorization of these groups depends on the level of the category; for example, artifacts are named faster than natural objects at a basic or subordinate level, whereas natural objects are categorized faster at a superordinate level (Lloyd-Jones & Humphreys, 1997).

In addition, Marí-Beffa et al. (2004) studied differences in animal and vehicle categorization on the subject of the semantic processing of words. These researchers found reaction time to living prime words was faster than for non-living prime words in a categorization task. Living words were found to be more salient, which accounted for the faster reaction time during categorization. Reaction time was conversely slower for living prime words when they were being searched for a particular letter because of the reduced saliency of the word as a whole.

Results from studies using PET and fMRI have not been conclusive about categorization differences between natural and artifactual categories (Devlin, Russell, et al., 2002). Kiefer (2005) suggested that such inconclusive results could be due to the limited time resolution of PET and fMRI technologies, rendering them less likely to detect category-related brain activity. Therefore, the superior time resolution of ERP recordings may be necessary to observe

differences in categorization for small or rapidly decaying signals. ERP technology is used in the present study for this reason.

Mouchetant-Rostaing and Girard (2003) found that the N170 component is a trigger to the face-specific global structural process showing the detection of physiognomic features. At the N1 component used by Kiefer (2001), which corresponds to the N170 component used by other researchers, natural categories were categorized faster than artifactual categories. Since animals have faces and vehicles do not, this observation is not surprising. According to Adolphs (2001), the neural system for processing faces (the fusiform gyrus) does not distinguish between stimuli that are actual faces and stimuli that are non-faces but that have a similar structure to a face.

Objects in the world are perceived within a context. Context involves aspects of the internal and external environment that are present during object perception (Clark & Carlson, 1981; Spear, 1978). When objects in the environment are perceived, context therefore plays a role in the perception of the objects. Both internal (mood, age, etc.) and external (surrounding noise, lighting, etc.) context play a role in perception (Murray et al., 1990).

Certain types of objects are typically found in certain contexts. For example, animals are typically found in fields or in other natural scenes, whereas vehicles are usually on a street or in a parking lot. Our knowledge of objects includes information about context— we usually think of an object in a context in which it would be likely to be found. The purpose of the present study was to explore the categorization of animals and vehicles in (a) a congruent context, (b) a homogeneous context, and (c) an incongruent context. Three ERP components were observed to study categorization: N170, N250, and P300. The N170 is a negative component occurring about 170 ms after stimulus onset. It is thought to represent the process of encoding faces (Eimer,

2000). Holcomb and Grainger (2007) found that the N250 represents processing at the level of form representations (e.g. general shape of an object). The P300 component reflects decisional processing, marking the final stage of cognitive processing (Desmedt, 1980). Increased amplitude and reduced latency of these components are indicative of effective and quick visual processing, respectively.

Effects of external context, specifically of the visual background in which a particular object is viewed, was of interest in the present study. To examine the role of context in adult categorization of animals and vehicles, three experiments were conducted. In Experiment 1, adults were tested for categorization of animals and vehicles in a congruent context (e.g. an animal in a field or a vehicle in a parking lot) and in the absence of a context (e.g. an animal or a vehicle situated in a homogeneous white background). In Experiment 2, adults were tested for categorization of animals and vehicles in a congruent context and in an incongruent context (e.g. an animal in a street, a vehicle in a field). In Experiment 3, adults were presented with animals and vehicles in a congruent context in both conditions; in one condition, the background was the one in which the photograph was originally taken, in the other, the object was extracted from that background and placed in a different congruent background.

## **Experiment 1**

This experiment was designed to test adult categorization of animals and vehicles in a congruent background and of animals and vehicles in a homogeneous background. For the stimuli used in this experiment, a congruent background refers to the background in which a photograph was taken, and is appropriate for the object. For example, a photograph of a tiger had a field of grass as a background, and a photo of a sports utility vehicle had a street as a background (see Figure 1). In the homogeneous background condition, the object was extracted

from the photograph and placed in a homogeneous white background, resulting in the absence of a context. The presence or absence of context was the independent variable, and it was hypothesized in this experiment that the presence of context would facilitate categorization, resulting in greater amplitude and reduced latency of N170, N250 and P300), whereas the absence of a context would hinder it, resulting in reduced amplitude and increased latency of N170, N250 and P300.

## Method

### *Participants*

Participants were recruited from Colby College in Waterville, Maine. Each participant was paid ten dollars. Two males (one of Asian descent, one of Hispanic descent) and 13 females (one of Pacific Islander descent, 12 of European descent) were tested. The majority of participants were college-aged, and ages ranged from 18-40 years. One of the female participants was left-handed; the rest of the participants were right-handed.

### *Apparatus*

Testing took place in a dark room. Each participant sat in a chair 60 cm from a (34 cm width by 27 cm height) Dell computer monitor. Two dark color opaque screens occluded the participants' view of the surrounding area. A video camera was mounted above the computer screen, and it was centered on the participant's face to allow for the experimenter to observe the gaze of the participant during testing.

### *Stimuli*

There were two categories of stimuli (animals and vehicles) in two conditions (congruent background and homogeneous background): 1) a single animal in a congruent background, 2) a single vehicle in a congruent background, 3) a single animal in a homogeneous background, and 4) a single vehicle in a homogeneous background (See Figure 1). The animals were a bear, bird,



cow, elk, horse, monkey, sheep, squirrel, and tiger; the vehicles were a coup, delivery truck, hatchback, motorcycle, pick up truck, sports-utility vehicle, sports car, utility golf cart, and VW Bug. The images, figure and ground, were approximately 23.6 cm high by 28.4 cm wide (visual angle: 21.4° high by 25.3° wide); figures were approximately 18.5 cm high by 23.7 cm wide (visual angle: 17.1° high by 21.5° wide). The average animal was 21.5 cm high by 19.3 cm wide (visual angle: 19.7° high by 17.9° wide) and the average vehicle was 15.5 cm high by 28 cm wide (visual angle: 14.4° high by 25° wide). In the congruent background condition, animals were shown in nature scenes (e.g. field or forest) and vehicles were shown in street scenes (e.g. roads). In the homogeneous background condition, the images were extracted from their backgrounds and placed in a white background.

### *Procedure*

Participants were presented with 18 full-color digitized images from one condition containing 72 trials of 9 animals and 9 vehicles, and after a period of a few minutes of rest they were presented with 36 images from the other condition containing the same animals and vehicles. The order of presentation of the stimuli was randomized, and whether the congruent background or homogeneous background condition was tested first was alternated between each participant. Each stimulus was presented in the center of the monitor for 500 ms. Between each stimulus, a blue screen was shown for 1800-2200 ms.

### *Recording of EEG*

The EEG was recorded with the EGI (Electrical Geodesics Incorporated, Eugene, OR) 64-channel HydroCel Geodesic Sensor Net (GSN). An adult (size medium) sensor net was used for all participants. Each sensor net has a geodesic arrangement, including specific locations for the vertex, nasion, ears, and eyes. The EEG was referenced to the vertex, which was determined

by the intersection of the midpoint between the ear-to ear measurement and the nasion to occipital protuberance measurements. The midpoints and the intersection were marked with a wax pencil. After the net was positioned, it was inspected to ensure proper placement of the electrodes and impedance was checked to ensure that the electrodes were recording properly. Participants were instructed to try not to blink, or to blink during the presence of the blue screen between stimuli if necessary.

### *ERP Waveform Analysis*

The EEG signal was referenced to the vertex, recorded with 20K amplification, at a sampling rate of 250 Hz, with band pass filters set at 0.1-100 Hz, and with 50  $\Omega$  impedance. Continuous electroencephalographic data were processed using NetStation 4.2 (EGI, Eugene, OR) and segmented into trials consisting of the 100 ms before the stimulus was presented (baseline trials) and the 1000 ms after the stimulus was presented. Data were digitally filtered with a 40-Hz low-pass elliptical filter and a 0.3 Hz high-pass filter and subsequently edited for artifacts. Artifacts were identified on individual channels if the signal amplitudes exceeded 200  $\mu$ V or if a blink occurred (defined on the basis of a difference between the two electrodes on the sensor net on the outside canthii of the eye and the two electrodes above the eye). For each participant, an average was computed for each stimulus type (animal in congruent background, animal in homogeneous background, vehicle in congruent background, vehicle in homogeneous background), and the data were referenced to the average reference. A baseline correction was applied to the 100-ms prestimulus recording interval and to the 1000-ms poststimulus recording interval. The number of good trials (trials without eye blinks or other movement interference) and the number of bad trials (trials containing eye blinks or other movement interference) were identified. Data were used in statistical analyses if there were at least ten good trials for both

animals and vehicles in each condition. The average number of good trials for animals was 28.71 out of 36 trials and the average number of good trials for vehicles was 28.82 out of 36 trials.

### *Quantification of ERP*

ERP averages were done to create plots and topographical maps. The averages were made from appropriate EEG segments, and were calculated 100 ms before stimulus onset through 1000 ms after onset.

Six components have been identified with previous work in this area. These components are the N170 component occurring 140-190 ms poststimulus onset, the N250 component occurring 230-320 ms poststimulus onset, and the P300 component occurring 290-411 ms poststimulus onset. The N170 component was observed in the occipital region ( $O_Z$ ) and in temporal regions ( $T_R$  and  $T_L$ ). Mean data were analyzed from clusters of electrodes of the EGI sensor net that corresponded to these regions. N170 peak amplitude and latency were analyzed from occipital (35, 37, 39; " $O_Z$ ") and from right and left temporal (44, 47; " $T_R$ " and 29, 30; " $T_L$ ") electrode sites. N250 and P300 peak amplitude and latency were analyzed from parietal (33, 34, 36, 38; " $P_Z$ "), central (16, 21, 41, 51; " $C_Z$ "), and frontal (3, 6, 8, 9; " $F_Z$ ") electrode sites.

## Results and Discussion

The analyses assessed differences in both amplitude and latency for each location and time window in separate ANOVAs.

To address the question of whether N170 differs at  $O_Z$  for object type and background, two 2 x 2 ANOVAs were conducted with object category (animal, vehicle) and background condition (congruent, homogeneous) as within-subject variables. The analysis for latency revealed a main effect for background,  $F(1, 14) = 6.087$ ,  $p < .05$ , with homogeneous background

being slower than congruent ( $M = 36.889$ ,  $SD = 1.253$ ;  $M = 34.878$ ,  $SD = .981$ , respectively). No other main effects or interactions were found.

To investigate the question of whether N170 differs for object type, background and side of brain ( $T_R$  vs.  $T_L$ ), two  $2 \times 2 \times 2$  ANOVAs were analyzed with object category (animal, vehicle), background (congruent, homogeneous), and side of brain (right, left) as within-subject variables. The analysis for amplitude revealed a main effect for location,  $F(1, 14) = 9.456$ ,  $p < .01$ , with the right side being more negative in amplitude than the left ( $M = -.505$ ,  $SD = .255$ ;  $M = .143$ ,  $SD = .192$ , respectively) (See Figure 2). No other significant effects or interactions were found.

To address the question of whether N250 differs for object type, background and region of brain, two  $2 \times 2 \times 3$  ANOVAs were conducted with object type (animal, vehicle), background (congruent, homogeneous) and brain region ( $P_Z$ ,  $F_Z$ ,  $C_Z$ ) as within-subject variables. A main effect for object was found for amplitude,  $F(1, 14) = 4.606$ ,  $p < .05$ , with vehicles showing greater negative amplitude than animals ( $M = -.479$ ,  $SD = .190$ ;  $M = -.035$ ,  $SD = .287$ , respectively) (see Figure 3). A main effect for location was also found for amplitude,  $F(1, 14) = 10.459$ ,  $p < .01$ , with  $P_Z$  and  $F_Z$  displaying greater amplitude than  $C_Z$  ( $M = 1.844$ ,  $SD = .581$ ;  $M = -1.839$ ,  $SD = .372$ ;  $M = -.776$ ,  $SD = .251$ , respectively). No other significant effects or interactions were found.

To look at the question of whether P300 differs for object type, background and region of the brain, two  $2 \times 2 \times 3$  ANOVAs were conducted with object type (animal, vehicle), background (congruent, homogeneous) and brain region ( $P_Z$ ,  $F_Z$ ,  $C_Z$ ) as within-subject variables. For amplitude, a main effect for object was found,  $F(1, 14) = 5.784$ ,  $p < .05$ , with vehicles showing greater amplitude than animals, ( $M = -.647$ ,  $SD = .187$ ;  $M = -.006$ ,  $SD = .288$ ,

respectively). Also, a main effect for location was found,  $F(1, 14) = 7.711, p < .05$ , with  $P_Z$  and  $F_Z$  displaying greater amplitude than  $C_Z$  ( $M = 1.019, SD = .595$ ;  $M = -1.433, SD = .353$ ;  $M = -.566, SD = .215$ , respectively).

In addition, an interaction between object and location was found,  $F(1, 14) = 7.589, p < .05$  (see Figure 4). Tests for Simple Effects were conducted to explore this interaction. A main effect was found at  $F_Z$  for object,  $F(1, 14) = 15.287, p < .001$ , with a greater amplitude found for vehicles than for animals ( $M = -2.281, SD = .381$ ;  $M = -.584, SD = .349$ , respectively). A marginal effect was found at  $C_Z$  for object,  $F(1, 14) = 3.773, p < .062$ , with a greater amplitude found for vehicles than for animals ( $M = -.725, SD = .198$ ;  $M = -.407, SD = .223$ , respectively). No significant effect of object was found at  $P_Z$ .

For latency, a main effect for location was found,  $F(1, 14) = 22.010, p < .001$ , with  $F_Z$  and  $C_Z$  showing greater latency than  $P_Z$  ( $M = 89.688, SD = 1.216$ ;  $M = 88.813, SD = 1.278$ ;  $M = 79.233, SD = 1.258$ , respectively). An interaction was found between object and location,  $F(1, 14) = 4.162, p < .05$ . Tests for Simple Effects were conducted to examine this interaction. A main effect was found at  $F_Z$  for object,  $F(1, 14) = 5.525, p < .05$ , with a greater latency for animals than for vehicles ( $M = 91.675, SD = 1.32$ ;  $M = 87.7, SD = 1.426$ , respectively).

These findings suggest that adults process images of objects within a context (e.g. in a congruent background) more quickly than in the absence of a context (e.g. in a homogeneous background). In addition, greater amplitude of activation generally occurs to vehicles than to animals are presented. There is also more activation in the frontal regions of the brain during later processing (around 300ms after stimulus onset). Other location differences occurred as a result of average referencing, which zeroes  $C_Z$ . The implications of these results will be discussed further in the General Discussion.

## Experiment 2

Experiment 2 was designed to test adult categorization of animals and vehicles in a congruent background and animals and vehicles in an incongruent background. It is possible that observed differences in categorization during Experiment 1 were due in part to a difference in the amount of information in the images shown. For example, images in the congruent condition contained more information present than images in the homogeneous condition due to the presence of a background in the image. Testing differences in categorization between congruent images and incongruent images will account for this difference, because they contain approximately equal amounts of information due to the fact that the images in both conditions contain both an image and a background.

Additionally, it is of interest to study differences between the processing of images in congruent vs. incongruent backgrounds. Results from Experiment 1 suggest that the presence of a congruent background, as opposed to the absence of a background, facilitates processing. It was therefore hypothesized that the presence of an incongruent background would make it more difficult to categorize the objects.

## Methods

### *Participants*

Participants were recruited from Colby College in Waterville, Maine. Each participant was given credit toward a Psychology course. Two males (of European descent) and 10 females (1 of Hispanic descent, 9 of European descent) were tested. All participants were college-aged, and ages ranged from 18-22 years. One of the participants was left-handed; the rest of the participants were right-handed.

### *Apparatus*

Experiment 2 used the same apparatus used in Experiment 1.

### *Stimuli*

There were two categories of stimuli (animals and vehicles) in two conditions (congruent background and incongruent background): 1) a single animal in a congruent background, 2) a single vehicle in a congruent background, 3) a single animal in an incongruent background, and 4) a single vehicle in an incongruent background (see Figure 1). The animals and the vehicles were the same as those used in Experiment 1, and the visual angles did not change. The congruent background condition was the same as in Experiment 1. In the incongruent background condition, the images were extracted from their backgrounds and placed in a background that was incongruous (e.g. an animal in a parking lot, a vehicle in a field).

### *Procedure*

The procedure was the same as in Experiment 1.

### *Recording of EEG and ERP Analysis*

Recording of EEG, ERP waveform analysis, and quantification of ERP were the same as in Experiment 1.

## Results and Discussion

As in Experiment 1, the analyses assessed differences in both amplitude and latency for each location and time window in separate ANOVAs.

To address the question of whether N170 differs at O<sub>z</sub> for object type and background, two 2 x 2 ANOVAs were conducted with object category (animal, vehicle) and background condition (congruent, incongruent) as within-subject variables. The analysis for amplitude revealed a main effect for object,  $F(1, 11) = 7.380, p < .05$ , with animals showing greater amplitude than vehicles ( $M = 0.171, SD = 0.293$ ;  $M = 0.000, SD = 0.284$ , respectively). The

analysis for latency revealed a main effect for background,  $F(1, 11) = 7.005, p < .05$ , with congruent background being slower than incongruent ( $M = 36.250, SD = .812; M = 34.847, SD = .598$ , respectively). No other significant effects or interactions were found.

To investigate the question of whether N170 differs for object type, background and side of brain ( $T_R$  vs.  $T_L$ ), two  $2 \times 2 \times 2$  ANOVAs were analyzed with object category (animal, vehicle), background (congruent, incongruent), and side of brain (right, left) as within-subject variables. No significant effects or interactions were found for amplitude or latency.

To address the question of whether N250 differs for object type, background and region of the brain, two  $2 \times 2 \times 3$  ANOVAs were conducted with object type (animal, vehicle), background (congruent, incongruent) and brain region ( $P_Z, F_Z, C_Z$ ) as within-subject variables. A main effect for location was found for amplitude,  $F(1, 11) = 18.114, p < .01$ , with  $P_Z$  displaying greater amplitude than  $F_Z$  and  $C_Z$  ( $M = 2.377, SD = .663; M = -2.634, SD = .502; M = -.382, SD = .243$ , respectively).

For latency, a main effect of location was found,  $F(1, 11) = 11.111, p < .01$ , with  $P_Z$  being slower than  $F_Z$  and  $C_Z$  ( $M = 72.875, SD = 1.294; M = 65.635, SD = 1.411; M = 69.625, SD = 1.248$ ). In addition, an interaction was found between background and location,  $F(1, 11) = 4.027, p < .05$  (see Figure 5). Tests for Simple Effects were conducted to investigate this interaction. A main effect was found at  $P_Z$  for background,  $F(1, 11) = 4.321, p < .05$ , with congruent background being slower than incongruent ( $M = 74.177, SD = 4.495; M = 71.573, SD = 6.575$ ). A main effect was also found at  $F_Z$  for background,  $F(1, 11) = 7.637, p < .05$ , with incongruent background being slower than congruent, ( $M = 67.365, SD = 6.308; M = 63.906, SD = 5.875$ , respectively). No other significant effects or interactions were found.



To look at the question of whether P300 differs for object type, background and region of the brain, two 2 x 2 x 3 ANOVAs were conducted with object type (animal, vehicle), background (congruent, incongruent) and brain region ( $P_Z$ ,  $F_Z$ ,  $C_Z$ ) as within-subject variables. For amplitude, a main effect for location was found,  $F(1, 11) = 10.204$ ,  $p < .01$ , with  $P_Z$  showing greater amplitude than  $F_Z$  and  $C_Z$ , ( $M = 1.354$ ,  $SD = .561$ ;  $M = -2.016$ ,  $SD = .518$ ;  $M = 1.535$ ,  $SD = .225$ , respectively). An interaction between object and background was also found,  $F(1, 11) = 5.657$ ,  $p < .05$ . A three-way interaction was found between object, background and location,  $F(1, 11) = 6.369$ ,  $p < .05$ . Tests for Simple Effects were conducted to investigate this interaction and the interaction between object and background. Three 2 x 2 ANOVAs were conducted with object type and background as within-subject variables for each location. At  $C_Z$  and  $P_Z$  no main effects or interactions were found. At  $F_Z$  an object x background interaction was found,  $F(1, 11) = 14.023$ ,  $p < .01$ . To further explore this effect, Tests for Simple Simple Effects were conducted. A one-way ANOVA was conducted with background as a within-subject variable. A main effect was found for background in the animal stimuli only,  $F(1, 11) = 10.068$ ,  $p < .01$ , with congruent having greater amplitude than incongruent, ( $M = -.305$ ,  $SD = .468$ ;  $M = -.263$ ,  $SD = .561$ , respectively).

For latency, a main effect for location was found,  $F(1, 11) = 29.417$ ,  $p < .01$ , with  $P_Z$  being faster than  $F_Z$  and  $C_Z$  ( $M = 79.406$ ,  $SD = 1.265$ ;  $M = 92.443$ ,  $SD = 1.332$ ;  $M = 86.396$ ,  $SD = 1.659$ , respectively). No other significant effects or interactions were found.

The results of this experiment provide conflicting results about the effects of congruent and incongruent backgrounds on latency. However, visual processing of objects in a congruent context is greater (i.e. displays greater amplitude at P300) than visual processing of objects in an incongruent context. As in Experiment 1, location differences occurred as a result of average

referencing, which zeroes  $C_z$ . The implications of these results will be discussed further in the General Discussion.

### **Experiment 3**

Experiment 3 was designed as a control to test the effects of extracting an object from the original background and placing it in another background on categorization. It is possible that some of the differences observed in the results of Experiments 1 and 2 could be due to the fact that the images in the homogeneous background condition and the incongruent background condition were manipulated images (i.e. the objects were extracted from their original background and placed in a different one). To account for this manipulation, images were extracted from the original background in which the photograph was taken and placed in another background that was congruent. This condition was named the manipulated congruent condition. In this way, the congruency of the image was maintained, whereas the manipulation of the image was variable. It was hypothesized that there would be no observed differences in processing between images in the congruent background condition and images in the manipulated congruent background condition, because the backgrounds remained congruent.

### **Methods**

#### *Participants*

Participants were recruited from Colby College in Waterville, Maine. Each participant was given credit toward a research participation requirement in a Psychology course at Colby. Two males (1 of Asian descent, 1 of European descent) and 9 females (2 of Asian descent, 7 of European descent) were tested. All participants were college-aged, and ages ranged from 18-22 years. One of the participants was left-handed; the rest of the participants were right-handed.

### *Apparatus*

The apparatus was the same as in Experiments 1 and 2.

### *Stimuli*

There were two categories of stimuli (animals and vehicles) in two conditions (congruent background and manipulated congruent background): 1) a single animal in a congruent background, 2) a single vehicle in a congruent background, 3) a single animal in a manipulated congruent background, and 4) a single vehicle in manipulated congruent background (see Figure 1). The animals and vehicles were the same as in Experiments 1 and 2, and the visual angles did not change. The congruent background condition was the same as in Experiments 1 and 2. In the manipulated congruent background condition, the images were extracted from their backgrounds and placed in a background that was congruent but not the original background in which the object was photographed. An example of an image in the manipulated congruent background condition would be a vehicle extracted from the driveway background and placed in another congruent background (e.g. a parking lot).

### *Procedure*

For Experiment 3 the procedure was the same as in Experiments 1 and 2.

### *Recording of EEG and ERP Analysis*

Recording of EEG, ERP waveform analysis, and quantification of ERP were the same as in Experiments 1 and 2.

## Results and Discussion

As in Experiments 1 and 2, the analyses assessed differences in both amplitude and latency for each location and time window in separate ANOVAs.

To investigate the question of whether N170 differs at O<sub>Z</sub> for object type and background, two 2 x 2 ANOVAs were conducted with object category (animal, vehicle) and background condition (congruent, manipulated congruent) as within-subject variables. No main effects or interactions were found for amplitude or latency.

To address the question of whether N170 differs for object type, background and side of brain (T<sub>R</sub> vs. T<sub>L</sub>), two 2 x 2 x 2 ANOVAs were analyzed with object category (animal, vehicle), background (congruent, manipulated congruent), and side of brain (right, left) as within-subject variables. The analysis for amplitude revealed a main effect for object,  $F(1, 10) = 5.634, p < .05$ , with vehicles showing greater amplitude than animals, ( $M = -.451, SD = .176; M = 1.198, SD = .115$ , respectively). No other significant effects or interactions were found.

To look at the question of whether N250 differs for object type, background and region of the brain, two 2 x 2 x 3 ANOVAs were conducted with object type (animal, vehicle), background (congruent, manipulated congruent) and brain region (P<sub>Z</sub>, F<sub>Z</sub>, C<sub>Z</sub>) as within-subject variables. A main effect for location was found for amplitude,  $F(1, 10) = 16.214, p < .01$ , with P<sub>Z</sub> and F<sub>Z</sub> showing greater amplitude than C<sub>Z</sub>, ( $M = 2.863, SD = .803; M = -2.968, SD = .588; M = -.604, SD = .425$ , respectively). No other significant effects or interactions were found.

To address the question of whether P300 differs for object type, background and region of the brain, two 2 x 2 x 3 ANOVAs were conducted with object type (animal, vehicle), background (congruent, manipulated congruent) and brain region (P<sub>Z</sub>, F<sub>Z</sub>, C<sub>Z</sub>) as within-subject variables. For amplitude, a main effect for object was found,  $F(1, 10) = 5.019, p < .05$ , with vehicles showing greater amplitude than animals, ( $M = -.239, SD = .190; M = -.007, SD = .168$ , respectively). A main effect for location was found,  $F(1, 10) = 13.010, p < .01$ , with P<sub>Z</sub> and F<sub>Z</sub>

showing greater amplitude than  $C_Z$ , ( $M = 1.766$ ,  $SD = .614$ ;  $M = -1.930$ ,  $SD = .418$ ;  $M = -.205$ ,  $SD = .250$ , respectively).

For latency, a main effect for location was found,  $F(1, 10) = 79.854$ ,  $p < .001$ , with  $P_Z$  being faster than  $F_Z$  and  $C_Z$ , ( $M = 77.375$ ,  $SD = 1.106$ ;  $M = 93.136$ ,  $SD = .747$ ;  $M = 88.097$ ,  $SD = 1.109$ , respectively). An object by background interaction was found,  $F(1, 10) = 7.156$ ,  $p < .05$ . Tests for Simple Effects were conducted to explore this interaction. A main effect was found for object type in the manipulated congruent background,  $F(1, 32) = 5.057$ ,  $p < .05$ , with animals being faster than vehicles, ( $M = 85.311$ ,  $SD = 8.116$ ;  $M = 87.394$ ,  $SD = 8.688$ , respectively). No other significant effects or interactions were found.

These findings suggest that there are no visual processing differences specifically for background between the congruent and the manipulated congruent conditions. In addition, vehicles appear to display greater amplitude than animals when being visually processed. As in Experiments 1 and 2, location differences occurred as a result of average referencing, which zeroes  $C_Z$ .

### General Discussion

In Experiments 1, 2 and 3, adults were tested for categorization of animals and vehicles in varying contexts using ERPs. Visual processing was facilitated by the presence of a context, as shown in Experiment 1. The N170 component analyses revealed that objects in a congruent background were processed more quickly (i.e. displayed decreased latency) than objects in a homogeneous background. The presence of a context therefore speeds up visual processing. No effects were found for amplitude, suggesting that the presence of a context makes processing more rapid but does not make it more definite (Maurage et al., 2007). No main effect of background was found for the P300 component, which is thought to be involved in higher order

processing (e.g. decision making such as categorization). As a result, no conclusions about higher-order processing can be made from this experiment. The results instead suggest that the presence of a congruent context facilitates faster visual processing (rather than faster or more definite categorization) than the absence of a context.

The type of context (e.g. congruent or incongruent) did not display conclusive results on visual processing; different components (N170, N250 and P300) showed different trends in amplitude and latency for the two conditions. However, the P300 component in Experiment 2 showed that animals in a congruent background exhibited greater amplitude than animals in an incongruent background. Because this component is associated with higher order processing, the facilitation of visual processing (indicated by the increased amplitude) in the congruent condition as opposed to in the incongruent condition could possibly be most significant. Therefore, the inconclusive results obtained for the N170 and N250 components could be considered negligible compared to the results of the P300 component. However, the difference was observable only for animals. These results are in concordance with Antal et al. (2001), who also found that P300 was greater for animals than for non-animals.

Kiefer et al. (2001) found similar results of picture and word categorization using ERP technology to the results of Experiment 2. Specifically, congruent target words were categorized more quickly (shorter latencies) than incongruent target words. This finding suggests that context, particularly the congruency of the context, plays a role in processing and categorization of both pictorial and verbal modalities. In particular, congruency of context facilitates processing in both domains, suggesting that this effect could exist in categorization of more domains (e.g. auditory, somatosensory, etc.).

The results of Experiment 3 provide justification for the stimuli used in Experiments 1 and 2. It was possible that any differences observed in amplitude or latency in the first two experiments could have been due to the fact that the stimuli in both the homogeneous and incongruent background conditions appeared unusual due to the fact they contained objects (animals or vehicles) that had been extracted from the original photo (the image used in the congruent condition) and placed in another background. This “photo-shopped” quality of the images in the homogeneous and incongruent conditions was not found to have had an effect of background on the amplitude or latency for any of the components. Because none of the background differences that were observed in Experiments 1 and 2 were found in Experiment 3, it can be concluded that the manipulation of the image (controlling for congruency) did not affect processing or categorization.

In all three experiments, it was generally observed with ERPs that vehicles showed greater amplitude (i.e. were visually processed in a more definite manner) than animals. Past research has not revealed conclusive evidence on the subject of processing or categorization of animals in comparison to vehicles. For example, at N170, Antal et al. (2001) found that non-animal stimuli showed greater amplitude than animal stimuli, whereas Thorpe et al. (1996) observed animal stimuli displaying greater amplitude than non-animal stimuli (including vehicles). The findings of the present study suggest a resolution to conflicting previous research, showing that at N170, N250 and P300 vehicles showed greater amplitude than animals overall. It is possible that humans categorized vehicles in a more definite manner than animals in these 3 experiments because in a college setting, vehicles are typically seen more frequently than animals. Therefore, they are more salient and better categorized by the participants. Perhaps this is the reason why the congruent background facilitated categorization compared to the

incongruent background in Experiment 2; vehicles were better processed in general and therefore the congruency of the context did not play as large a role as it did for the animals, which were typically not visually processed as well.

Overall, the findings from Experiments 1, 2 and 3 revealed that the presence of a context facilitated visual processing of objects. In addition, the congruency of the context played a role in categorization; specifically, animals were better categorized in a congruent background than in an incongruent background. The manipulated congruent condition was not found to show any background differences for processing or categorization, which allows for conclusions to be drawn from Experiments 1 and 2 based solely on the nature of the background. Both the homogeneous and the incongruent backgrounds were found to hinder processing and categorization, respectively. In order to explore the question of which context would better facilitate processing or categorization, a study should be conducted in the same manner as Experiments 1 and 2 using the stimuli in the homogeneous condition and the incongruent condition. In this way, the question of whether categorization is hindered more by the absence of a context or by an incongruent context could be investigated.



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## Figure Captions

*Figure 1.* Stimuli used in the homogeneous (a), congruent (b), incongruent (c), and manipulated Congruent (d) conditions in Experiments 1, 2 and 3.

*Figure 2.* Amplitude difference of  $T_R$  (a) and  $T_L$  (b) at N170 in Experiment 1.

*Figure 3.* Amplitude difference of animals and vehicles at N250 in Experiment 1.

*Figure 4.* Mean amplitudes of animals and vehicles at  $P_Z$ ,  $F_Z$  and  $C_Z$ , displaying an object by location interaction at P300 in Experiment 1.

*Figure 5.* Latencies (ms) of congruent and incongruent at  $P_Z$ ,  $F_Z$  and  $C_Z$ , displaying a background by location interaction at N250 in Experiment 2.

Figure 1

(a)



(b)



(c)



(d)



Figure 2

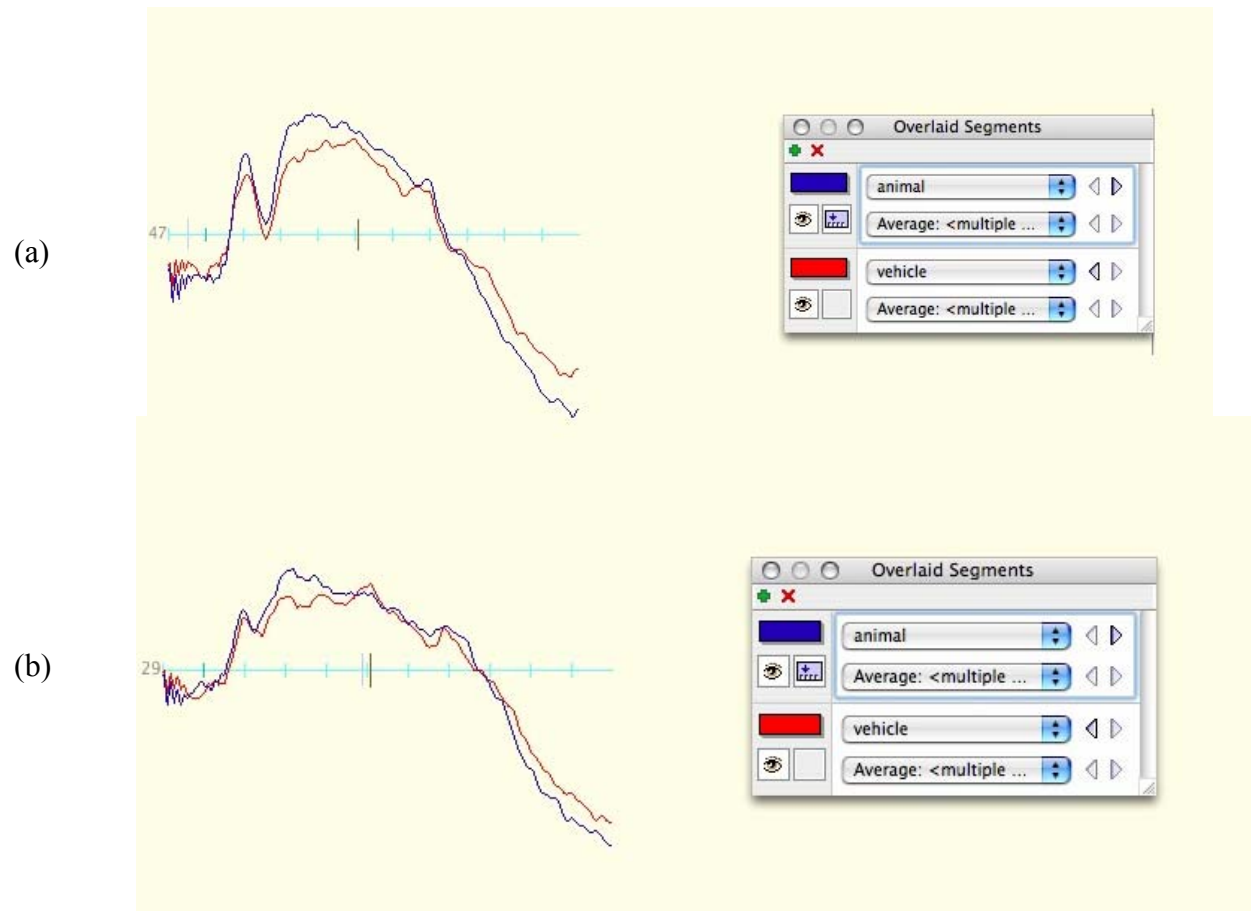


Figure 3



Figure 4

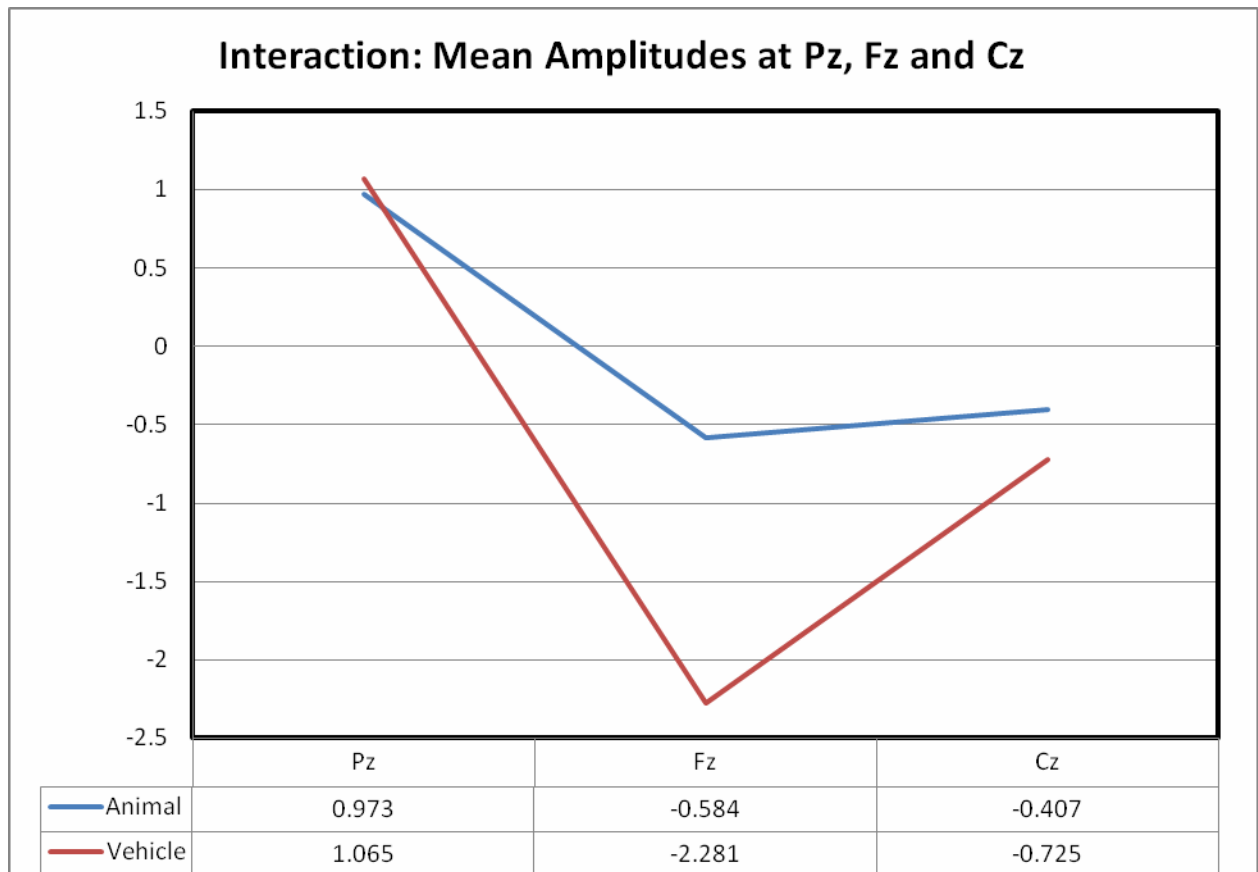




Figure 5

