Study Information

Project

- Functional set size in search in scenes.

Authorship

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Project Description

Search for objects in scenes (as opposed to simple shapes against a uniform background) can be influenced by scene context. For example, when looking for a mug, it is reasonable to assume that one would limit the area of search to surfaces such as tables and countertops, while ignoring the ceiling or the walls. A number of studies have investigated these effects of scene context on real world search (e.g., Ehinger et al., 2009; Neider & Zelinsky, 2006, 2008, 2010; Torralba, Oliva, Castelhano, & Henderson, 2006; Wolfe, Alvarez, Rosenholtz, Kuzmova, & Sherman, 2011; Wolfe, Võ, Evans, & Greene, 2011). An important contribution of these studies is the concept of the *functional set size* – the subset of the total set size that is relevant to the current goal of search. In these studies, reaction time to locate a target object is affected only by the number of items in the relevant area of the scene. The current project focuses on examining the functional set size in scenes in greater detail.

Research Question

Does the functional set size apply to efficient search in scenes?

Our lab recently demonstrated systematic variance in efficient search reaction times (Buetti, Cronin, Madison, Wang, & Lleras, 2016). Reaction times were found to increase logarithmically with set size in a fixed-target efficient search task. To account for this pattern of data, we proposed that visual search begins with the computation of a top-down contrast signal between each region of the scene and a target template held in memory. This involves an accumulation of evidence toward a *non-target* threshold. Regions of the scene that are sufficiently different from the target will accumulate enough evidence to reach this threshold. These regions are then excluded from further processing, while those that have yet to reach threshold undergo further processing.

In this study, we are interested in investigating the functional set size of efficient search with scenes. Wolfe et al. (2011) found that search in scenes was very efficient (around 5ms/item) and attributed it to the functional set size that is determined by the probably locations of the target. However, as Wolfe et al. (2011) also suggest, set size is difficult to determine for scenes. Neider and Zelinsky (2006) investigated set size effects in scenes, although they did it within an inefficient search context. Thus, it remains an open question as to whether the concept of a functional set size applies to search in scenes.

To this end, we designed an efficient search task in a scene that would allow for the control of set size. Observers were tasked to locate and determine the direction of an orange colored fish. Distractors were either grey fishes or grey birds. Importantly, the search display was clearly divided into the sky, where only birds were found, or the sea, where only fishes were found. Thus, if scene context influences efficient search, the number of birds in the sky (irrelevant set size) should not affect reaction times to find to target fish in the sea.

On the other hand, if exhaustive processing takes place across the entire display regardless of scene context information, then we would expect that the set size of birds in the sky to affect reaction times. If so, one of two possibilities exist. First, the birds would be processed exhaustively just like any other distractor, and thus introduce a logarithmic cost to search times (e.g., Buetti et al., 2016). Second, the birds could be rejected en masse, adding on a constant time cost to search times that is not affected by set size.

Design

This experiment is based on a pilot study that we ran in our lab (N=17).

The study will be a full-within 4 (bird setsize) x 4 (fish setsize) experiment. The setsizes would be: 0, 4, 8, and 16. It should be noted that the setsize refers to the number of lures (e.g. there would be a total of 5 fishes in the fish setsize 4 condition). There would thus be 16 cells in total. There would be 45 trials per cell for a total of 720 cells. The entire experiment will be divided into 9 blocks of 90 trials each, with a rest period after each block. Within each block, there will be an equal number of conditions that will be presented in a random order. Both the fish and bird distractors will be grey in color, while the target fish will be orange in color. All stimuli can be facing either the left or the right.

The stimuli will be randomly presented on a 12 x 12 grid, with the constrain that birds can only appear in the top half of the display, and fish can only appear in the bottom half. No stimulus will be presented in the borders of the grid, effectively making it a 10 x 10 grid. In addition, no stimulus will be presented in the two center rows of the grid where the “horizon” was located. Thus, there will be 80 possible locations (40 each for fish and bird) for stimuli to be presented. Random x and y jitter would also be added to each stimulus.

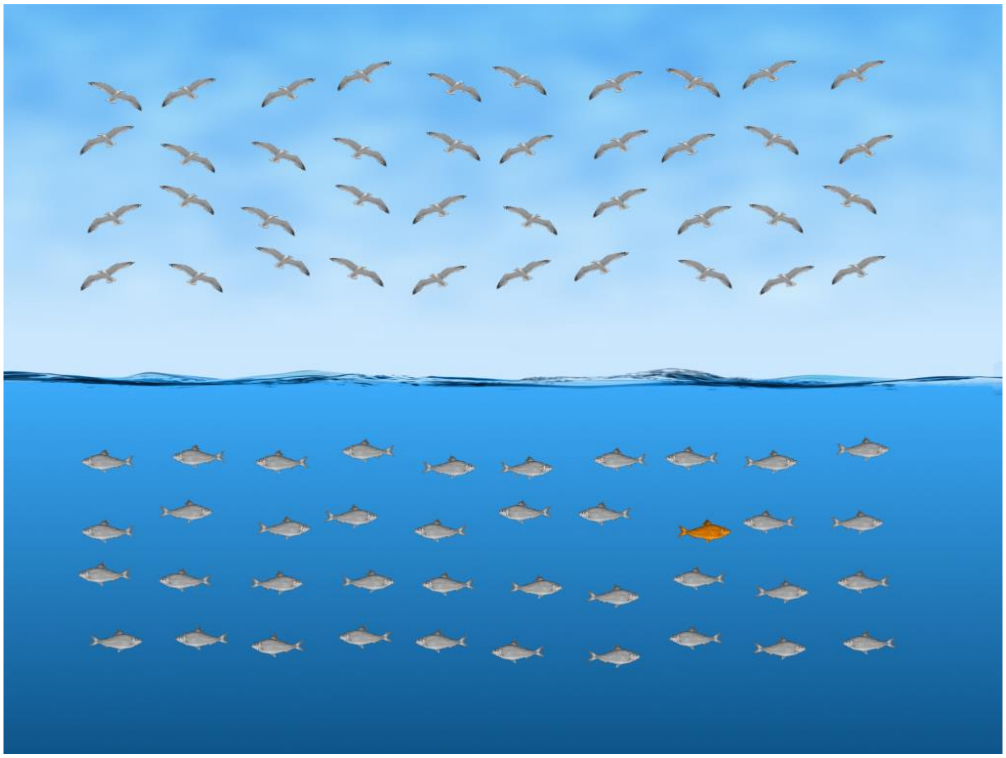

Figure 1. Illustration of all possible locations of stimuli

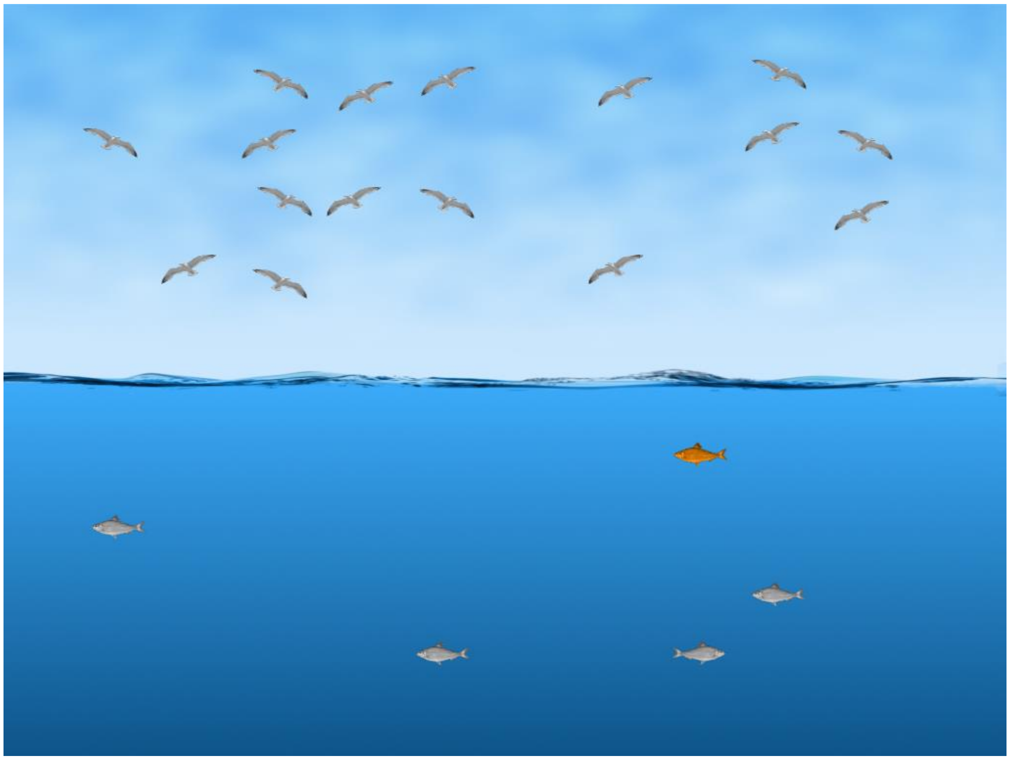

Figure 2. Example of a trial with set size 16 for the irrelevant region (birds) and set size 4 for the relevant region (fishes). Note that the set size refers only to the number of lures.

Each trial will begin with a central white colored fixation cross against a black background that will be presented for 500ms. The display will then be presented for a maximum of 3 seconds. Participants will be required to respond to the direction to which the target fish is facing. Upon response, the display will terminate and a blank screen will be presented for 1.5 seconds. The next trial then begins.

Feedback, in the form of a loud beep, will be given for incorrect responses. No feedback will be given for correct responses. The experiment is expected to last around 40 minutes. An example display is shown below.

Instructions and Procedure

The following instructions will be presented to participants:

Welcome!

This is a visual search experiment. You will be searching for an orange colored fish among some other fishes and birds

Your task is to decide which direction the grey fish is facing.

You will see examples next.

Upon acknowledging the instructions, participants will be shown the left-facing target and required to press the left arrow key to continue. After which, participants will be shown the right-facing target and required to press the right arrow key to continue. A practice block, with 16 trials (one from each experimental cell) will then commence. All stimuli will be presented on a 22-inch cathode ray tube monitor with a refresh rate of 186Hz and a screen resolution of 1024 x 768 pixels.

Exclusion criteria

Before or during data collection:

1. If a researcher error occurs such as providing the participant with the wrong instructions or not properly setting up the experimental conditions (e.g. program or lighting conditions). Participants will be allowed to complete the study, but a note will be made in the experimental log sheet and the participant's data will be excluded.
2. If the participant appears to be in an altered state due to being under the influence of a substance, or if they are extremely sleepy. A note will be made on the experimental log sheet and the participant's data will be excluded.

3. If the participant is not following instructions, then they will be given a warning upon first notice and a note will be made on the experimental log sheet. The data from that participant will then be excluded.

After data collection:

1. Participants with error rates greater than 10% will be removed from analyses.
2. Reaction times greater than 1500 will be assumed to be due to attentional lapses, and reaction times lesser than 200ms will be assumed to be due to anticipations (Wolfe, Palmer, & Horowitz, 2010). These will be removed from analyses. In our pilot data, this represented only 1.06% of all trials.

Analyses and hypotheses

The dependent variables that will be collected are:

1. Reaction times
2. Accuracy

Since the main goal of this experiment is to examine whether items in irrelevant regions (i.e. birds in the sky while looking for fish in the water) are processed in efficient search, our measure of interest is reaction times.

Logarithmic and linear slopes will be fitted to the reaction times for the relevant and irrelevant lures separately. We expect to see better logarithmic compared to linear fits (measured by both R^2 and AIC values) at least for the relevant lures. This would extend our model to another new stimulus set (cf. Buetti et al., 2016; Wang, Buetti, & Lleras, 2017)).

If scene context influences efficient search, the number of birds in the sky (irrelevant set size) should not affect reaction times to find to target fish in the sea.

If the entire search display is processed in efficient search regardless of scene context information, then the set size of the irrelevant region would affect reaction times. There could be one of two possibilities:

1. The irrelevant lures would add a logarithmic cost to search time just like the relevant lures (e.g., Buetti et al., 2016)
2. The irrelevant lures would be rejected en masse and add on a constant cost (i.e. not affected by set size e.g. Humphreys & Müller, 1993).

Participants

Participants will be recruited from the student population of the University of Illinois at Urbana-Champaign. They will receive either course credit or monetary compensation. Only participants who have normal color vision will be recruited for the study.

Based on our pilot study (N=17), the required sample size to determine an effect of $\eta_p^2 = .076339$ at 90% power is 32. This corresponds to the effect size of the set size of the irrelevant region (birds) on reaction times.

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