Asynchronous presentation and capacity issues: The ABC of visual search

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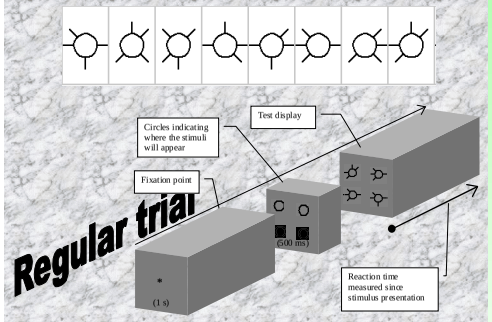
Introduction

The present research explored two new approaches to understand results obtained in visual search paradigms: i) the analytical approach used distribution analyses; ii) the empirical approach used asynchronous presentation of the test displays.

Very difficult stimuli were used to magnify the results, and extended training to reduce variability.

Method

- 4 subjects completed 75 hours of training;
- there was 4 targets and 4 distractors;
- Display sizes were small (D=1, 2 or 4);
- Errors had to be kept low (ss did 1.5% false alarm and 4% miss);
- Targets were defined by a conjunction of two features (diagnostic features) accompanied by two irrelevant features.



General conclusion

The new methods proved useful: visual search with these difficult stimuli was mostly serial (but a few guesses interrupted some trials early) and benefited a little from a very fast and parallel preprocessing of the display. Also, search was slow to initiate when display size was large (which may be required for the preprocessing stage to occur).

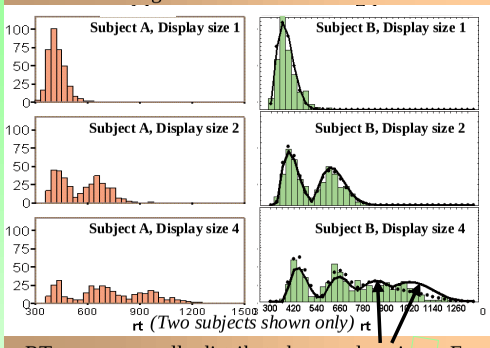
A- Architecture of search

Is search serial or parallel?
Is stop exhaustive or self-terminating?

When search finally **begins** *(see A.2), it is serial self-terminating with a small percentage of "target-absent" guess (see A.1). These two effects yield a negative to positive ratio situated between 1.2:1 and 2:1 and negative variance that is equal to positive variance.*

A.1- Stop and guessing

RT distributions for target-present responses. These results can only be obtained with a serial and self-terminating search. Let's look closer...

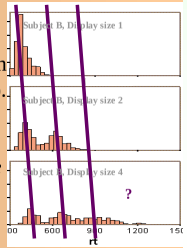


RTs are not equally distributed across locations. For example, the last location is visited only 11% of the times (instead of the expected 25%).

This suggests that long RTs are more likely to be interrupted by a guess. The number of missing RTs correlates well with the number of misses and their distributions.

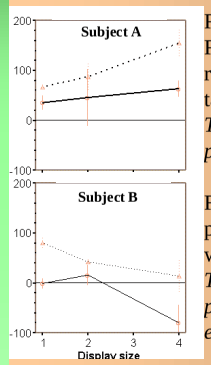
A.2- Start and preparation

Search does not start right from the moment when the stimuli are presented (similar distribution were reported by Hockley, 1984). *This suggests a preparation phase, possible because subjects know how many locations will be filled (see A.2a). This phase really occurs before processing starts (see A.2b).*



A.2a- Is there a preparation phase when no circles cue the occupied locations?

During transfer 2 (sessions 50..55), on half the trials, no circles where shown after the fixation star. We subtracted the RTs from those of regular trials.

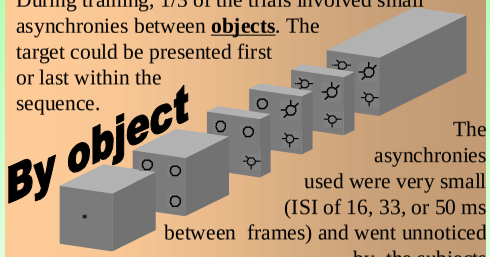


Results showed an increase in RT for subject A (with a 2:1 ratio for target absent vs. target present), *This suggest that the preparation phase is embedded in the search*

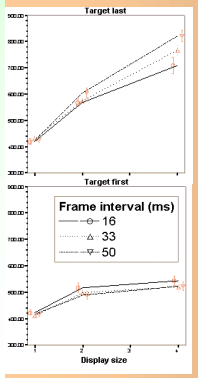
For subject B, we see a progressive decrease in RT, with a 1:1 ratio. *This suggests that the preparation phase is done exhaustively for that subject.*

A.2b- If search is serial, target should be treated First-In, First-out (FIFO)

During training, 1/3 of the trials involved small asynchronies between **objects**. The target could be presented first or last within the sequence.



The asynchronies used were very small (ISI of 16, 33, or 50 ms between frames) and went unnoticed by the subjects



When the target was last, the RTs were increased by exactly (D-1) times the frame duration, as expected from a serial model.

When the target was first followed by three distractors, it is detected as fast as when it is followed by only one distractor. *Apparently, the first two are first in. This confirms that subjects are doing something else at the very beginning of a trial.*

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B- Identification process

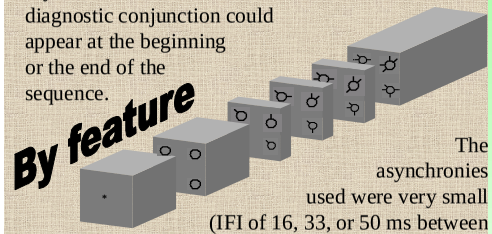
Are features used in the identification process, or a more holistic recognition method used? If features are used, are the diagnostic features unitized in one perceptual unit?

It is important to mention that the subjects were unaware that diagnostic features defined the targets.

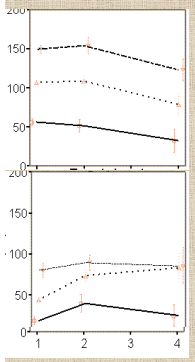
The identification process used the feature information. The subjects tried to decide by categorizing the objects (using only the 2 diagnostic features; see B.1). The diagnostic features were given priority because capacity was limited (see B.2). No unitization seemingly took place at the end of training.

B.1- Presenting by feature

During training, 1/3 of the trials involved small asynchronies between **features** so that the diagnostic conjunction could appear at the beginning or the end of the sequence.



The asynchronies used were very small (IFI of 16, 33, or 50 ms between frames) and were not noticed by the subjects. We subtracted RTs from regular trials.

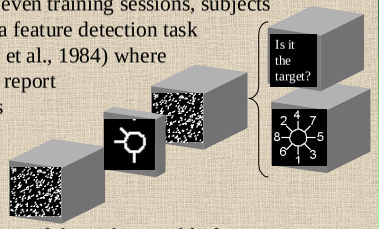


When diagnostic features were presented last, RTs were increased by exactly three times the frame duration (ISI), that is, the time to present all the features,

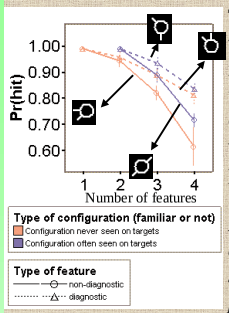
When diagnostic features were first, the effect was 1/2 smaller, suggesting that they waited for about two of the four features to be presented before deciding. *Diagnosticity was learned and used by the subjects.*

B.2- Capacity of the identification process

During the even training sessions, subjects performed a feature detection task (Townsend et al., 1984) where they had to report the features seen.



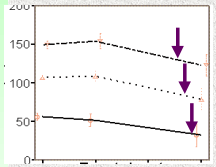
Up to four out of the eight possible features were randomly presented on each trial.



The accuracy decreased as the number of features increased. Non-diagnostic features and unfamiliar configurations (never seen on targets) had lower performance.

Results suggest that subjects, at the end of training, were still capacity-limited and preferred to rehearse diagnostic information.

C- Temporal resolution of attention



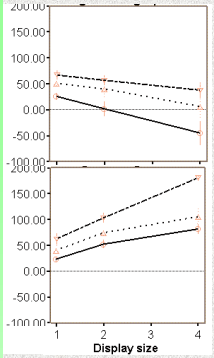
On many occasions, the data showed some benefits for large displays (which is also apparent in A.1). This could be explained by assuming that there is some preattentive attraction of attention with small (but significant) efficiency.

Attraction of attention operated even with conjunctively defined stimuli. It was more efficient when displays were large and when diagnostic information was present at only one location at a time (see C.1). Also, attraction of attention generated false alarms when features were presented for a very brief amount of time (see C.2). This suggests that locations are not coded preattentively.

C.1 Confirming attraction of attention

Can attention be attracted by conjunctions?

During transfer 3 (sessions 65..69), if diagnostic features of the target were presented first, the diagnostic feature of the distractors were presented last (or vice-versa). The target's diagnostic features were therefore at only one location very early in the trial in the first condition. We subtracted RTs from those of the regular trials.



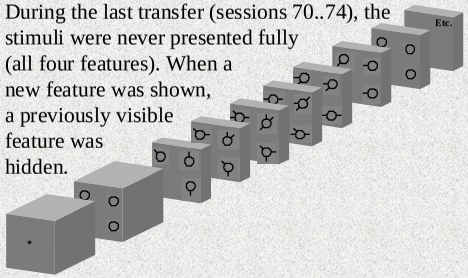
Performance was best for large display size (even compensating for the asynchrony) when targets revealed their diagnostic information first.

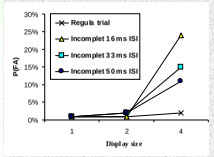
In the opposite condition, performance was worst because subjects' attention was directed to distractors location (since they all had one of the two diagnostic features).

C.2 Illusory conjunctions

Is attraction of attention a rapid phenomenon?

During the last transfer (sessions 70..74), the stimuli were never presented fully (all four features). When a new feature was shown, a previously visible feature was hidden.





A new phenomena: False alarms! They occur only for larger display size (as suspected above), and were more numerous for very short IFI.This is contrary to intuition: if the images are almost simultaneous, they should superimpose and there should be no difference with a really simultaneous presentation.