Effective visual short-term storage capacity and speed of encoding are affected by arousal

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Capacity and Encoding Speed are affected by Arousal

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ABSTRACT

Several Effects of spatial cueing on visual attention have been thoroughly investigated within the last 30 odd years. Similar to spatial cueing, temporal cueing seem to afford a performance enhancement to a subject if he or she knows when in time an event will occur (Coull & Nobre, 1998). Manipulation of time intervals between a cue and the stimulus onset or the fore periods has been shown to be an effective method of manipulating arousal level. When using accuracy rather than reaction time in experiments the subject's performance is not confounded by motor movements allowing a manipulation on the perceptual level (Vangkilde & Bundesen, 2009).

Here a manipulation of fore periods was performed combined with a whole report paradigm allowing measures of basic attentional parameters such as memory capacity (*K*) and speed of processing (*C*). The manipulation of fore periods was divided into either a high or a low expectancy condition using a geometric distribution of the waiting times. We find that speed of processing (*C*) increases within the high expectancy condition compared with the low expectancy, memory capacity (*K*) on the other hand show a decrease in the high arousal condition compared to the low.

The TVA model (Bundesen, 1990) would predict that a change in speed of processing (*C*) with this manipulation; however, memory capacity (*K*) should not be affected. We speculate that selection may be affected by the boost in arousal in one of two ways; either by an effect in the filtering mechanism where filtering is less effective under the high arousal condition or that arousal effects targets and distracters differently in a way that boosts distracters slightly relative more than target objects.

INTRODUCTION

In a pilot experiment Sørensen (2010) investigated the reliability of measures of visual short-term memory capacity (*K*) and processing speed (*C*). The results suggested that *C* may be less stable between test sessions than *K*. Despite an effort to keep external variables constant between test sessions, state variables like arousal of the individual observers probably varied between sessions. The Theory of Visual Attention (TVA; Bundesen, 1990) suggested the interpretation that a variation in the level of arousal would affect *C* but leave *K* unaffected. Here we wanted to investigate effects of arousal manipulations by varying the observers' temporal expectations by use of different foreperiod distributions while measuring their performance by use of TVA.

EXPERIMENT

Design

Experiment 1 combined a temporal expectancy paradigm (Vangkilde & Bundesen, 2009) with a whole report paradigm (Sperling, 1960) which yielded estimates of visual short-term memory capacity (K) at two different levels of temporal expectancy. In either temporal expectancy condition, the foreperiod from the presentation of a warning cue to the presentation of the stimulus display was geometrically distributed. Experiment 2 expanded the whole report into a partial report design (Sperling, 1960) allowing estimation of observers' ability to filter targets from distracters (parameter alpha). Experiment 3 introduced an intermediate level of temporal expectancy into the design from Experiment 2. Finally, in Experiment 4, waiting times were blocked by condition to ease the observers' ability to distinguish between the three temporal expectancy conditions.

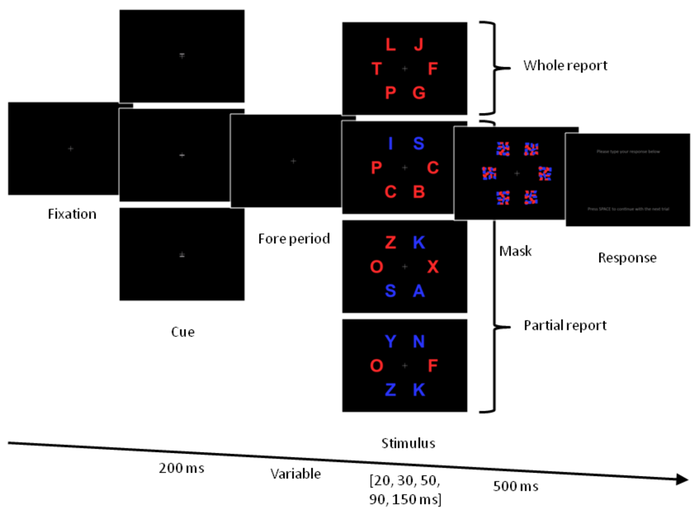

Figure 1: Each trial was initiated by a fixation, which was then followed by a cue and then variable fore periods dependant on the cue type. A memory-set was presented for variable exposure durations (20-150ms), followed by a mask for 500 ms, and finally a report screen was displayed.

Participants

There were 8 participants in each of the four experiments. The participants were all students at the University of Copenhagen.

RESULTS

The TVA parameters were estimated from the data using the LIBTVA toolbox (Dyrholm et al., submitted).

Experiment 1

In Experiment 1, we replicated results reported by Vangkilde and Bundesen (2009): Manipulating the level of temporal expectancy by changing the probability of success underlying the geometric distribution of foreperiods affected *C*, but not t0. Thus, *C* was higher in a high temporal expectancy condition compared with a low expectancy condition. To our surprise, *K* tended to be slightly lower in the high compared with the low expectancy condition.

Experiment 2

In Experiment 2, we replicated the results for whole report found in Experiment 1. We also introduced a partial report condition which made it possible to estimate observers' ability to filter out distracting information. Selectivity was higher (i.e., parameter alpha was smaller) in the high temporal expectancy condition.

Experiment 3

In a third experiment, we introduced a condition with an intermediate level of temporal expectancy. Here we found the expected pattern for parameters *C* and alpha, but no clear effects on *K*.

Experiment 4

In Experiment 4, waiting times were blocked by condition to ease the observers' ability to distinguish between the three foreperiod conditions. However, the results were similar to those of Experiment 3.

DISCUSSION

The results of Experiments 1-4 suggest that, with increasing temporal expectancy, processing speed *C* increased, whereas the temporal threshold for perception, t0, remained constant. The efficiency of selecting targets rather than distractors also increased, but the results concerning possible effects on the available short-term storage capacity *K* were inconclusive.

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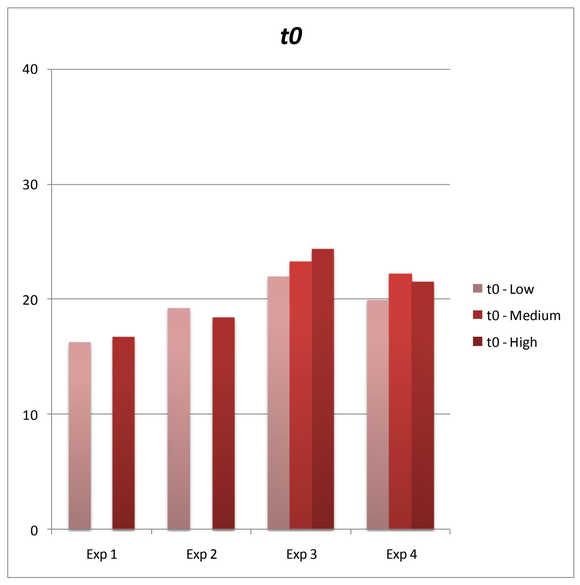

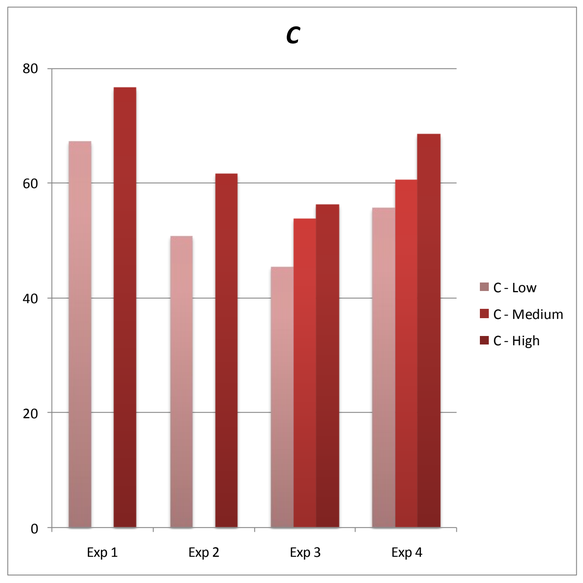

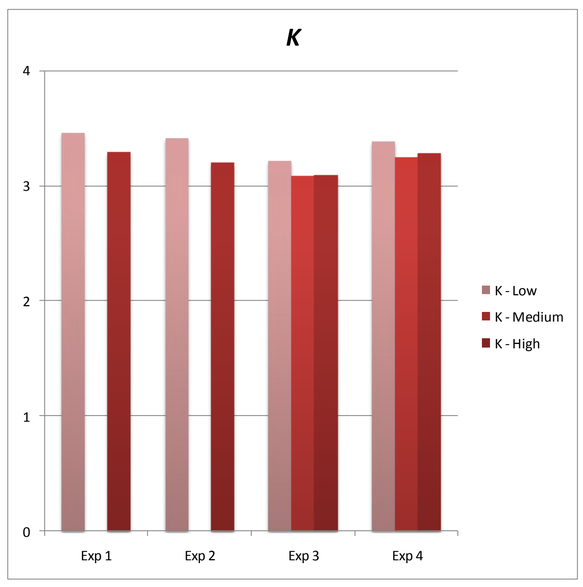

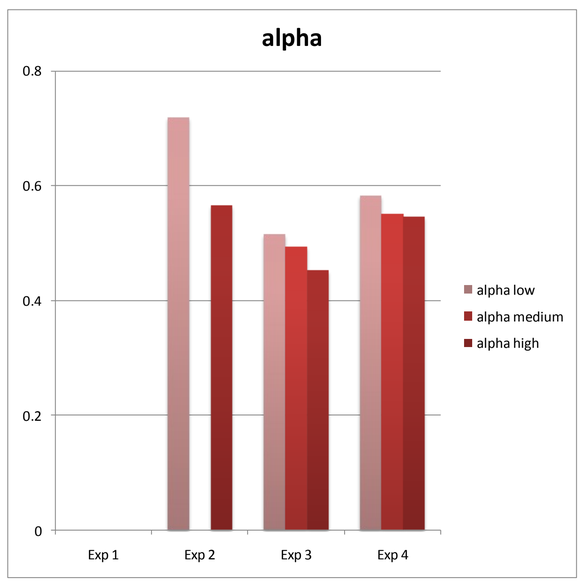

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