Sequential expectation of target locations affects allocation of attention

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We examined whether, and to what extent, the sequential expectation of targets at more than one location facilitates the processing at expected locations by using a color-discrimination task for sequentially presented targets. In Experiment 1, targets were presented sequentially at one of eight iso-eccentric placeholders. In 80% of trials, the target location was regularly shifted in the clockwise direction for each target presentation. In 20% of trials, the second target appeared at a random location except for the next clockwise position. The reaction times (RTs) were shorter for the second target presented at not only the expected second, but also the expected third, location than presented at other locations. The results of Experiment 1 were basically replicated in Experiment 2 in which a longer sequence than Experiment 1 was used. These results show that attention is controlled by sequential expectation of target locations. Attention can facilitate visual processing on locations of up to at least two future events.

**Key words:** visual attention, attentional control, sequential expectation of target locations

The expectancy of a spatial location facilitates the processing of a target presented at the location (e.g., Posner, Snyder, & Davidson, 1980). In this study, we examined whether, and to what extent, the sequential expectation of more than one target location facilitated processing at the expected locations. The goal of the present study was to verify the following predictions: (1) Attention which isallocated to multiple locations is based on the sequence of targets. (2) The sequential expectation of more than one location facilitates processing at the expected locations.

**Experiment 1**

**Method**

**Observers** Eighteen observers participated as paid volunteers.

**Apparatus and Stimuli** A color AV-tachistoscope with a 21 inch monitor was used. A red or green spot (1° of visual angle in diameter) was presented for 100 ms as a target. The fixation display contained eight placeholders in a circular array (10° in diameter).

Each observer was seated 60 cm away from the monitor and their eye movements were recorded.

**Procedure** Each observer performed a color-discrimination task for sequentially presented targets with 900 ms of SOA and responded to the target color by pressing one of two keys assigned to a color. The observers were required to keep their eyes on the fixation dot while they performed the discrimination task. There were two types of target displays: four target and two target. In one type of display four targets were presented sequentially on one of eight placeholders. In the other displays two targets were presented sequentially on one of eight placeholders. In 80% of the trials (regular trials) the target location was regularly shifted in a clockwise direction for each target presentation. In the remaining 20% (irregular) of the trials the second target appeared at a random location, except for the next clockwise position. In the four-target displays the third and fourth targets appeared at the clockwise location of the second target.

**Prediction of the results**

We focused on the performance to the second target as a function of relative location to the first target. A definition of the relative location is as follows. When the second target was presented at the same location as the first, this was defined as "0", when presented in a clockwise direction from the
first target location this was from "+1" to "+4", and from "−1" to "−3" was used when the second target was presented in a counterclockwise direction from the first target location. We predicted that, if attention could be allocated to multiple locations, then processing of the second target should be facilitated compared to presentation of the target at the first target location (0). In addition this would occur not only when the second target appeared at the expected second location (+1) in the regular trials, but also when the second target accidentally appeared at the expected third (+2) or fourth (+3) locations in the irregular trials (Figure 1a).

**Results and Discussion**

The RT to the second target as a function of the relative locations is shown in Figure 1b. In the regular trials (+1) of the four-target displays the RTs were shorter for the second target. But this was true in the irregular trials only when the second target was presented at the expected third location (+2). In the two-target displays the RTs were shorter for the second target only in the regular trials (+1). A location which was clockwise to the expected second target did not exhibit facilitation, and this excluded the possibility of a general enhancement at clockwise locations of the first target. These results revealed a facilitation of processing not only at the expected (second) target location but also at the subsequent (third) location in four-target displays. The results also indicated that attention is allocated to two target locations occurring in the future according to the sequence of the targets.

**Experiment 2**

We examined whether a longer sequence of targets expanded the facilitation of processing at expected locations.

**Method**

**Observers** Seventeen observers participated as paid volunteers.

**Procedure** The methods were the same as those in Experiment 1 except for the length of the sequence of the targets. Seventy-one targets were presented in each sequence. Eighty percent of the targets appeared at the next clockwise location to the previous target. The remainder of the targets appeared at a random location, except for the next clockwise position. As a control condition, sixty-five targets were randomly presented with an equal probability at one of the eight placeholders.

**Results and Discussion**

The RTs were shorter not only at an expected location but also at a subsequent location. Under the control conditions, the RTs were constant across the relative locations. These results again indicated that attention is controlled by the sequential rule of target locations.

**General discussion**

In Experiments 1 and 2 we showed that attention was allocated to the subsequent locations of two targets according to the sequence of the targets. We provide evidence that attention is controlled by a sequential expectation of the target locations. Dynamic allocation of attention can facilitate visual processing at locations of up to at least two future events.

**References**