When do actively controlled visual events guide our attention?

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Introduction

Visual perception, attention, and action seem to be interdependent. Actions are based upon perceived visual stimuli and attention to certain features of such stimuli is guided by a sense of agency over their actions (Jordan & Knoblich, 2004). Control over the orientation change of target stimuli during a modified visual search task led to faster Reaction Times (RTs) to locate the targets (during active-control trials) than when orientation change was computer-controlled (during passive-control trials) (Pilling & Barrett, 2017). However, this action-control advantage (difference in average RTs calculated by taking away the mean RT during active-control trials from passive-control trials) was only examined when distractor orientation change-rate was constant and set size was varied. The current study attempted to pinpoint where this action-control advantage was most prominent using a modified visual search task, across a range of distractor orientation change-rates, whilst holding set size constant.

Method

Twelve participants carried out a computer-based modified visual search (see Figure 1). Participants had to find the target that changed orientation horizontally/vertically and report its colour. The speed at which participants located the target was measured in RTs, in milliseconds (ms). Participants were presented active- and passive-control trials, using a games-controller to change the target's orientation during active-control trials. Half the distractors changed orientation and half remained static (see Figure 2), all at a maximum tilt of ±6 degrees away from the horizontal/vertical axis.

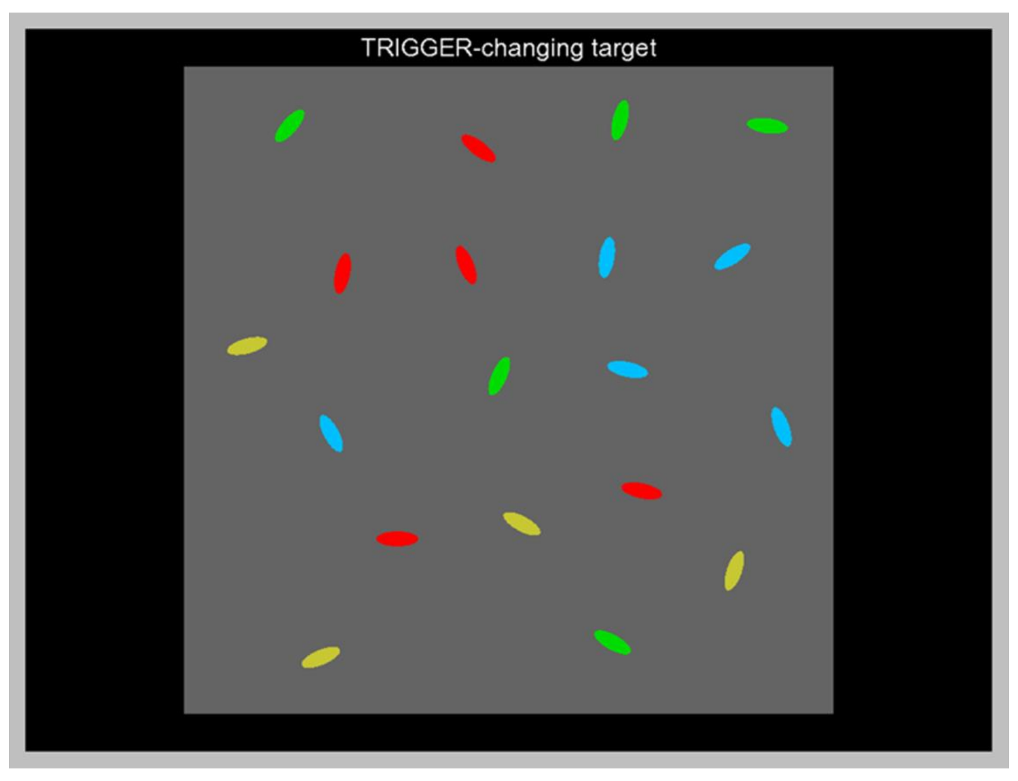

Figure 1. Example of a search-display used in the modified visual search task, during an active-control (trigger-change) trial. All search-displays presented 20 coloured ellipses (19 distractors, 1 target).

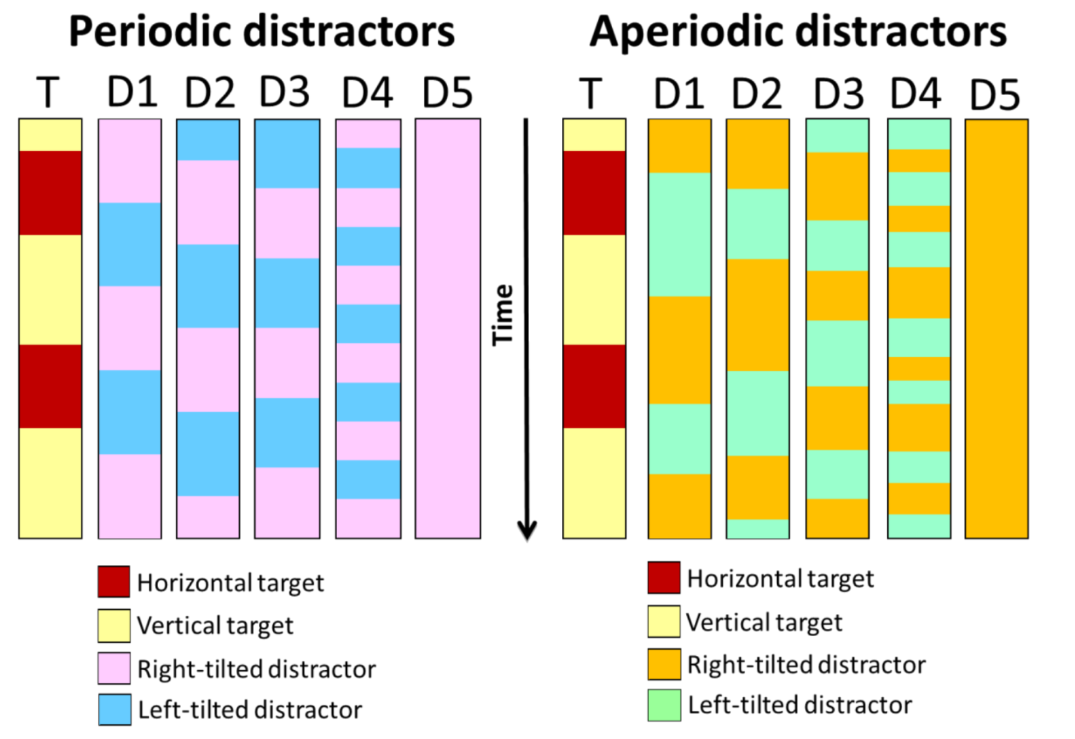

Figure 2. A schematic illustrating the time course for distractors changing orientation, alongside the target stimulus. Distractors changed orientation at either 1.11Hertz (Hz) (D1), 2.38Hz (D2), 5.56Hz (D3), or 16.67Hz (D4), all either in a regular, 'periodic' change-pattern, or an irregular, 'aperiodic' change-pattern.

Results

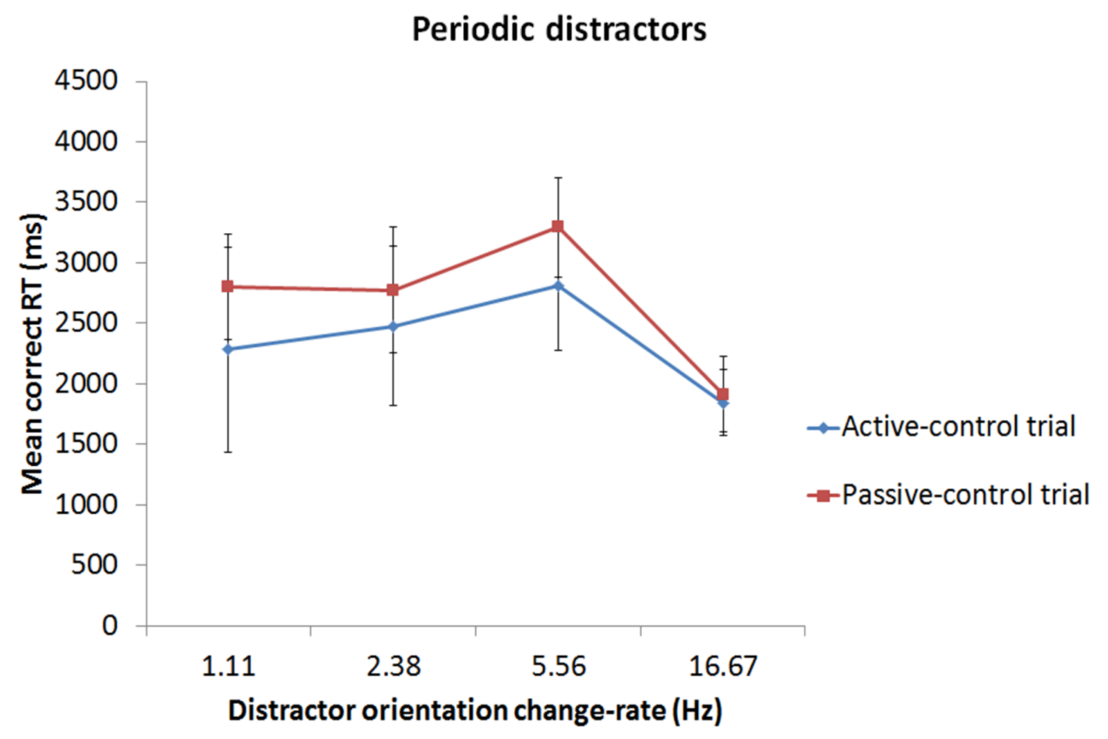

Figure 3. The RT distribution (in ms) for locating the target stimuli, plotted separately for active- and passive-control trials, during *periodic* distractor presentations.

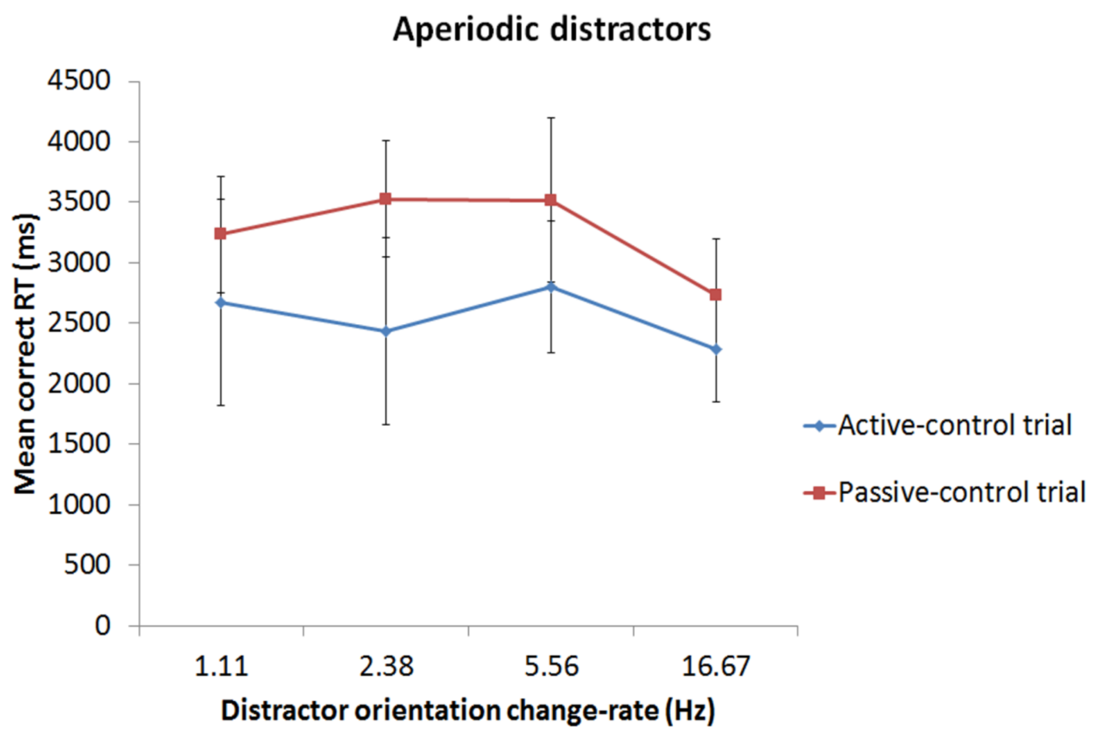

Figure 4. The RT distribution (in ms) for locating the target stimuli, plotted separately for active- and passive-control trials, during *aperiodic* distractor presentations.

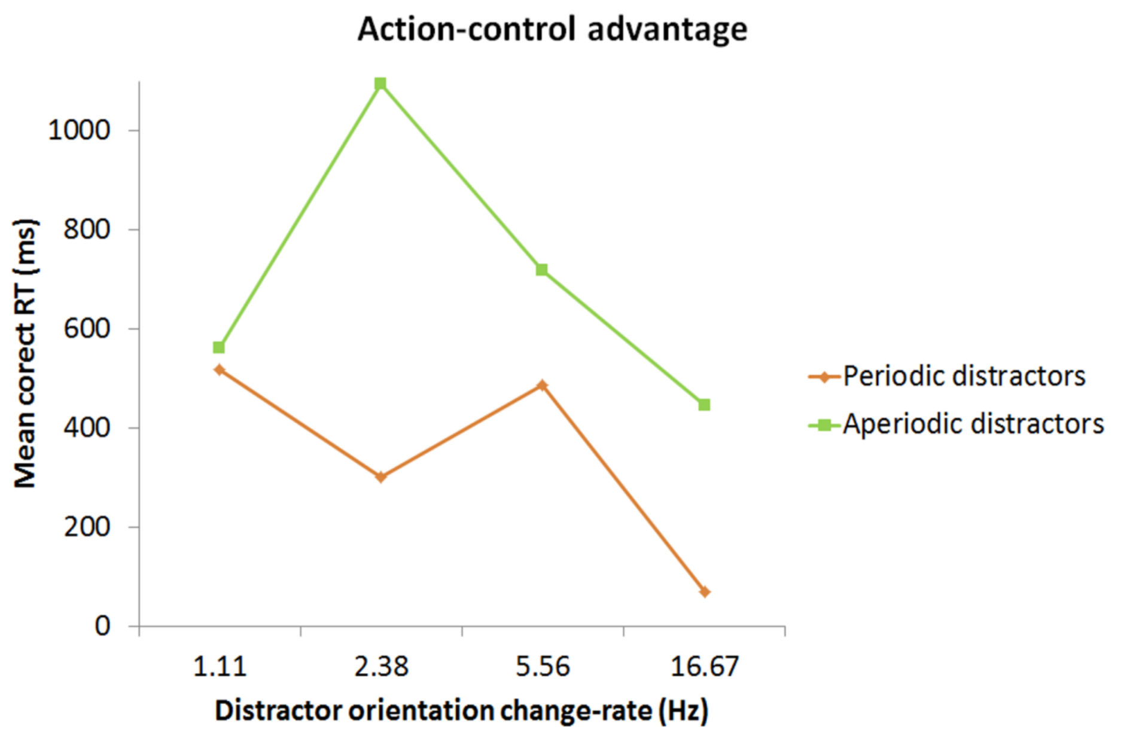

Figure 5. The action-control advantage (RTs in ms) across all trials, plotted separately for periodic and aperiodic distractors.

Participants were significantly quicker at reporting targets during active- than passive-control trials (F[1,11]=6.536, p=.027, η_p^2=.373). RTs were quicker with distractors changing orientation at 16.67Hz and slowest at 5.56Hz (F[1,11]=6.654, p=.001, η_p^2=.377). Periodic and aperiodic distractor presentations during active-control trials yielded significantly quicker RTs than passive-control trials (F[1,11]=5.591, p=.038, η_p^2=.337). Faster RTs were exhibited when distractors changed orientation at 16.67Hz and slowest with distractors at 5.56Hz (see Figure 3 and Figure 4), independent of distractor change-pattern (F[1,11]=3.234, p=.035, η_p^2=.227). The action-control advantage was strongest with aperiodic distractors changing orientation at 2.38Hz and weakest with periodic distractors at 16.67Hz (see Figure 5).

Discussion

Participants were reliably quicker at locating targets during active-control trials, suggesting agency improves one's attention to target stimuli (e.g. Salomon, Lim, Kannape, Llobera, & Blanke, 2013; Pilling & Barrett, 2017). What might be driving the action-control advantage? It could be the synchrony between the temporal output of the participants' target orientation change and the visual displays (Salomon et al., 2013) or synchrony between one's action and seeing its corresponding effects (Grèzes, Frith, & Passingham, 2004). However, further research systematically manipulating the extent of agency over targets would validate whether agency or a *sense of agency* drives the search. The action-control advantage might have been greatest with aperiodic distractors slowly changing orientation due to increased target-distractor heterogeneity based on differences between target and distractor orientation change-rates (Wolfe & Horowitz, 2017). These differences could reflect differences in processing the target's and distractors' ongoing activity (Zacks, 2004). Further research needs to focus on distractor features which guide attention during visual search, moreover, whether this action-control advantage is unique to visual stimuli changing orientation, or whether colour change, for example, also produces similar findings.

References

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