Posner paradigm in real-life: an augmented reality study

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Introduction

Human brain constantly receives lots of information that it is unable to process efficiently and simultaneously. For efficient processing, we need to select the important information and ignore the irrelevant one according to our goal (Driver, 2001). This attentional selection is crucial in situations that require rapid actions such as driving and piloting, air traffic control operations, or surgical tasks, especially if the patient's life is in danger (Trick et al., 204; Romer et al., 2014; Imbert et al., 2014; Ghazanfar et al., 2015; Gray et al., 2016; Soret et al., 2019).

To improve this attentional selection, it is possible to use visual cues to guide attention and thus increase the speed and accuracy of the information processing (Hameed et al., 2007; Booth et al., 2013; Tonnis & Klinker, 2016). In the visuospatial area, this selection process is called attentional orienting (Posner, 1980). It refers to our attentional shifting ability in a region of the visual space to prepare the processing of information (likely to be) contained in this region of space. In the most widely used Posner cueing task (an attentional orienting paradigm), a target appears to the left or right of a central fixation point on a computer screen. A cue is provided to the participant first to inform the user of the target's onset location. Classic results show faster response times when the cue provides correct information (valid cue) about the target's location rather than incorrect information (invalid cue). This effect is observed with eye movement towards the target area (overt orienting) or without eye movement (covert orienting). By comparing the response times between the conditions of cue validity and cue invalidity it is possible to determine the effectiveness of the cue to direct attention.

This paradigm, which is mainly used on a standard computer screen in the laboratory, has recently been adapted to virtual reality and shows similar effects (Soret et al., 2019; Soret et al., 2020). This experiment was the first to show that Posner's paradigm could be transferred to immersive environments. However, if virtual reality is more ecological than laboratory conditions, it does not incorporate tangible objects. This is why, in this study, we wanted to determine if Posner's paradigm also works when tangible objects that must be caught are used to gain ecological validity.

Therefore, we asked participants to pick up an object in front of them as quickly as possible using a cue projected through a video projector. We used endogenous (voluntary orienting, top-down) and exogenous (automatic orienting, bottom-up), valid and invalid cues. Our hypothesis is that valid cues will allow the participant to pick up the object faster than invalid cues. There could also be a difference in processing speed depending on cue type (endogenous/exogenous).

Materials and Methods

Twelve volunteers participated in the study. The experiment consisted of a Posner task in which participants had to pick up an object as quickly as possible to the left or right of a central fixation point in front of them. A red light flash (target) indicated the object to take. Before this target, a cue was provided to the participant (200 ms presentation). The cue was either a white light flash at one of the two object or a left/right directional arrow located on top of the central fixation point. Each cue was presented 40 times.

They indicated 30 times the correct position of target onset and 10 times the wrong position (75% predictivity). Participants were instructed not to move their eyes during the entire task (covert orienting) and to use the cue to shift their attention. The target appeared 300 ms after the cue offset. Once the target appeared, participants took the targeted object by removing it from its base. The scalpel bases were connected to an Arduino Nano and consisted of two receiving pods. A conductive copper strip was stuck on the object to conduct the electric signal between the two pods (see figure 1). Before each trial, an automatic script verified that the object had been returned to its base. When the object was removed from its support, the signal was interrupted, and the response times could be recorded. The Arduino Nano was connected to a PC (Alienware R17) under which the task was run using MATLAB and the Psychtoolbox. The task was projected horizontally on the experiment table using a video projector suspended vertically above the table (table height = 70cm). Participants had to pick up the object with the nearest hand

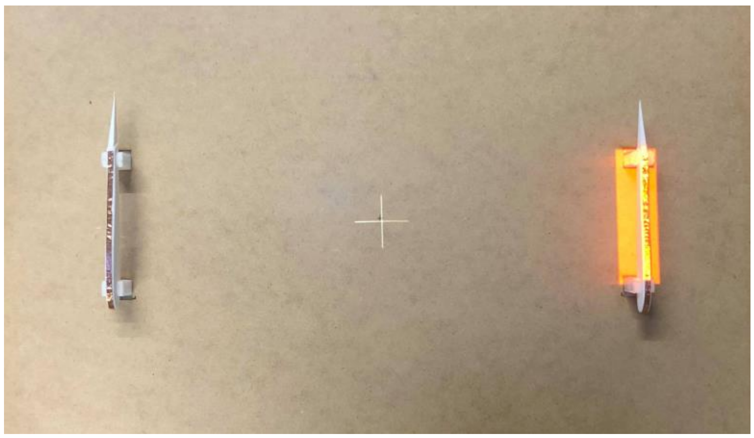

Figure 1. The experimental set-up with conductive bases, two scalpels, fixation cross and target presentation.

Results

The results were analyzed using MATLAB and JASP software. We observed the effects of the factors cue validity (valid/invalid) and cue types (endogenous/exogenous) on subjects' response times. The 2-factor repeated measures ANOVA shows a main effect of cue validity as in the original Posner experiment, $F(1,11)$=27.108, p=.0002, $\eta^{2=}$0.398. Valid cues produced faster response times than invalid cues (MD = 77 ms). We also observe a marginal effect of cue type, F(1,11) = 4.196, p=.065, $\eta^{2=}$0.103. Endogenous cues tend to produce faster response times than exogenous cues (MD = 39 ms). There is no interaction, F(1,11 = 0.914, p=0.360).

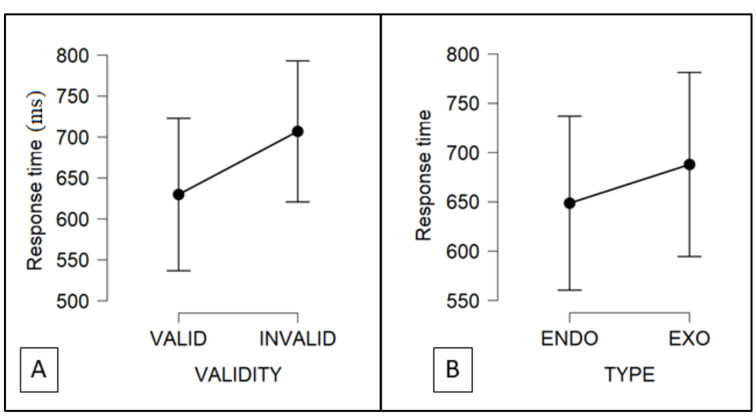

Figure 2. A) The principal effect of validity; B) The marginal effect of cue type

Discussion

These results show that Posner's paradigm, far from being a simple synthetic laboratory paradigm, produces effects also in an ecological environment where users must perform a concrete action on tangible objects. It would seem that endogenous cues could be chosen to promote rapid treatment, but further studies are needed.

To our knowledge, this one of the first experiments to reproduce this paradigm with cue validity effect in real life with tangible objects that must be caught. It shows the need to transfer experimental paradigms out of the laboratory and test them in ecological environments to develop concrete applications. It is thus possible to imagine augmented reality systems by adding information by superimposition to guide professionals in their practice. Specifically in environments that often require fast and efficient reactions to preserve the safety of individuals, such as aircraft cockpits, air traffic control towers, and surgical blocks.

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