Free viewing vs. watching with a view to planning functional grasps of tools: an eye-tracking study

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INTRODUCTION

Tools are a special category of objects: their visual structures (affordances), and the perceived functional identities are thought to **automatically "potentiate" relevant actions** (e.g., Creem-Regehr & Lee, 2005; Michałowski & Króliczak, 2015) – **including proper eye movements** (Desanghere & Marotta, 2011) – even in the absence of overt tasks (cf. Belardinelli at al., 2015). We tested this idea directly by asking subjects, who already participated in three experiments using the same sets of stimuli and tool-related tasks, to freely view these objects or to watch them with a view to planning functional grasps of these objects.

We hypothesized that watching with function in mind would result in more focused exploration of graspable parts.

METHODS

Participants

Twenty four right-handed collage-aged participants (13 females) between the ages of 19 and 25 years (mean age of 21.8 years SD=1.5) were tested. All participants had normal or corrected-to-normal visual acuity. Right hand preference was determined by a modified version of the Edinburg Handedness Inventory (Oldfield 1971).

Stimuli

The stimuli were high-resolution photos of 15 workshop, kitchen and garden tools presented at three different angles (0, 135, and 225^0) in their foreshortened perspectives, which emulate 3D viewing. Two of the used angles (135, 225^0) afforded easy functional grasps and one of them (0^0) required an uncomfortable hand rotation to perform functional grasps. The order of stimuli was randomized across participants and tasks.

Apparatus and Procedure

Participants were seated in a comfortable armchair and viewed the stimuli on a monitor positioned 60 cm in front of them. Eye movements were recorded by using Red, SensoMotoric Instruments GmbH (SMI) eye-tracker, with a sampling rate of 60 Hz and spatial resolution < 0.5^0.

The whole study consisted of two tasks: (1) the free viewing condition, and (2) the watching with a view to planning functional grasp condition.

Before the analyses of the eye-tracking data, Areas of Interest (AOIs) were delineated by dividing the tools into the grasp-related and the execution-related parts.

RESULTS

There was a main effect of the area (object part) covered by fixations in the two conditions, such that a significantly greater area was visually explored during free viewing $F(1,14) = 45.0$, $p < 0.001$, as shown by the number of saccades and their spread into the two AOIs. The difference between the two conditions is visualized using a single object in Figure 1 and 2.

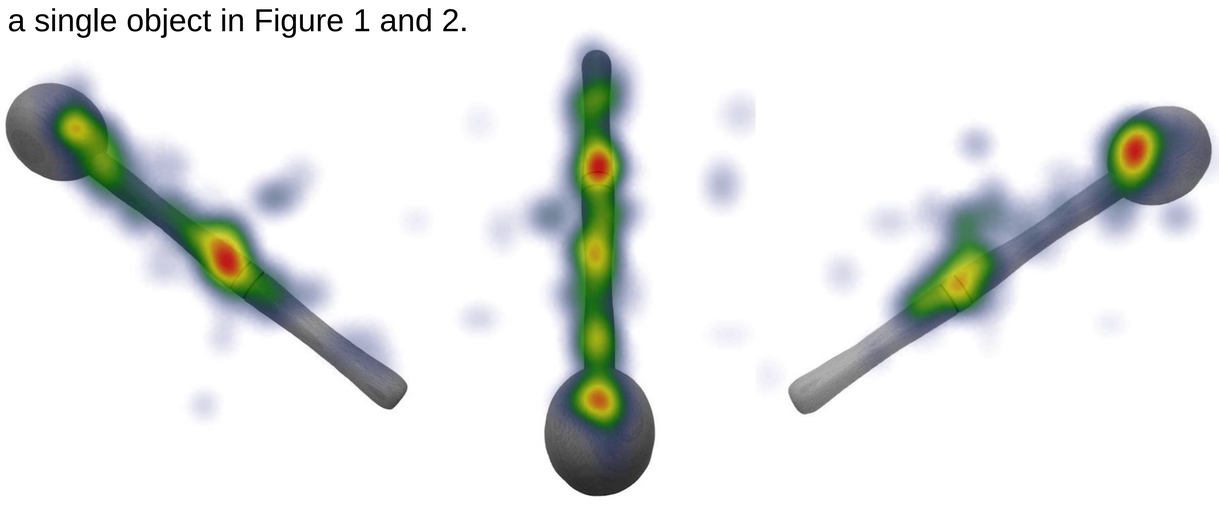

Figure 1. *The pattern of eye movements directed at the same object at three orientations when the participants were instructed to freely view the tools presented on the screen.*

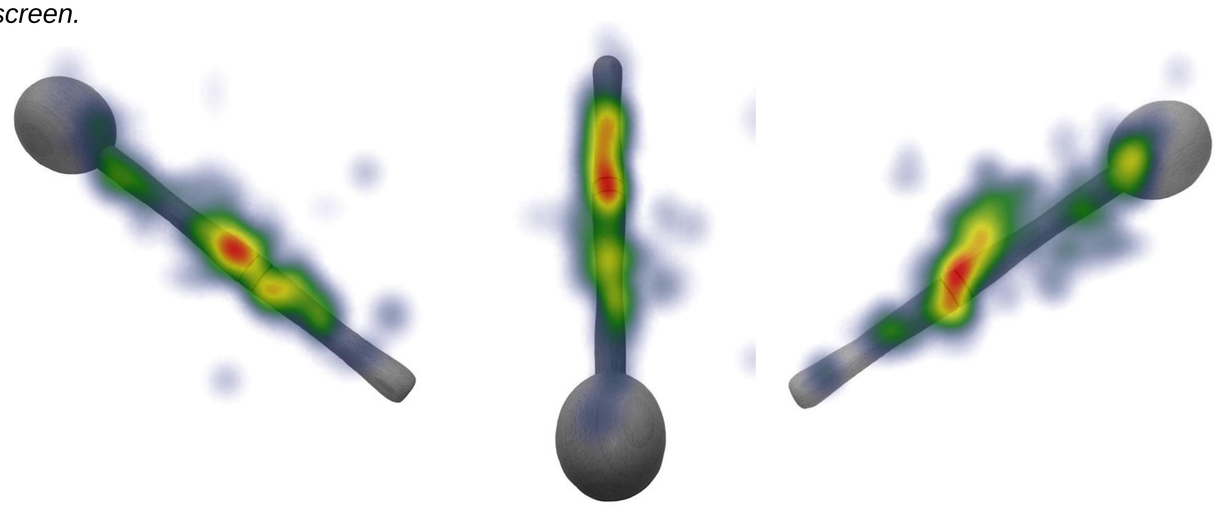

Figure 2. *The pattern of eye movements directed at these same objects when the participants were instructed to watch these tools with a view to planning functional grasps.*

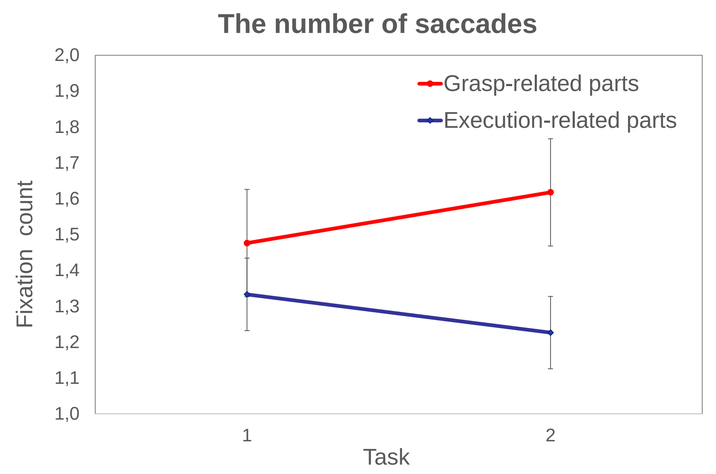

Figure 3. *The number of saccades as a function of task and AOI.*

This significant effect, now expressed as fixation count, is shown in Figure 3 as a function of the task. The difference between the number of saccades performed in the two AOIs was significant only in *the functional grasp* condition where significantly smaller number od saccades was observed in the execution-related areas.

In addition to a significant main effect of fixation dwell time $F(1,14)=56.1$, $p < 0.001$, such that graspable parts of the objects were explored longer regardless of the condition, there was a significant fixation time by task interaction, $F(1,14)=13.6$, $p =0.01$, such that only in the functional grasp condition the execution-related parts of the objects were fixated for significantly shorter time (see Figure 4).

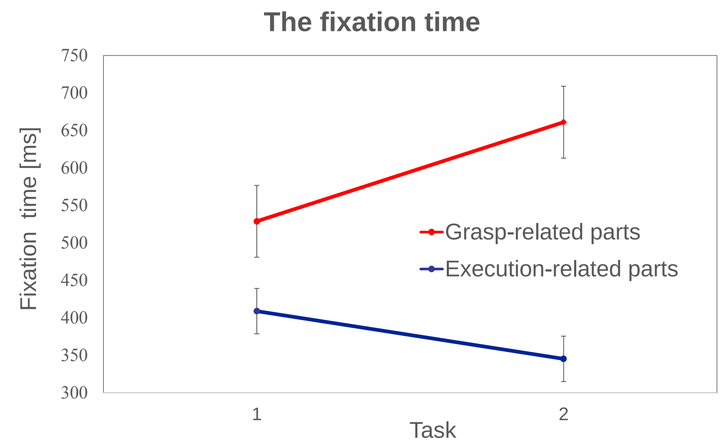

Figure 4. *The fixation time as a function of task and AOI.*

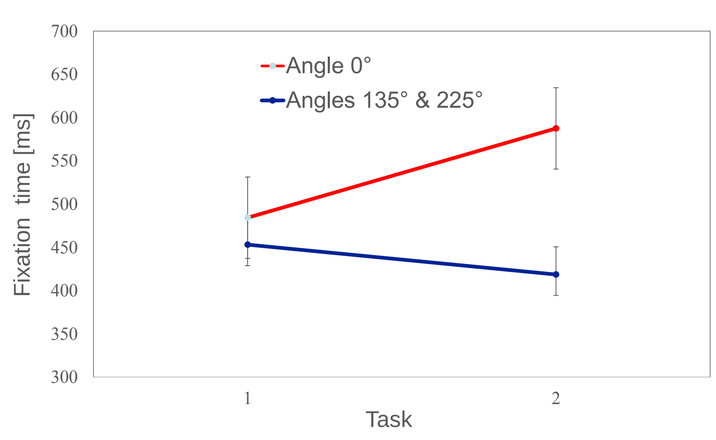

Figure 5. *The fixation time as function of stimulus angel*

Finally, there was a significant interaction between task and viewing angle ($F(1,14) = 5.4$, $p = 0.05$), such that the graspable parts of objects shown at the angle of 0^0 were fixated (visually explored) longer when the task was to watch with a view to planning functional grasping. In short, in the free viewing condition fixation time was distributed equally across differently angled objects. This effect is shown in Figure 5 on the left.

DISCUSSION

The way common tools are visually explored in everyday live is believed to depend on whether or not object affordances are automatically perceived and, therefore, potentiate relevant actions. This process was thought to be independent of internal representations of tools. If this were the case then the eyes should be spontaneously directed either towards the grasp-related or execution-related parts of the studied objects. This was not the case.

When tools were viewed freely, the saccades and gaze durations were distributed equally across different parts of these objects. On the other hand, when object functions were taken into account, the graspable parts were more extensively viewed. In other words, participants did not pay much attention to the execution-related parts when affordance discrimination was critical for task performance.

These results clearly show that even the visual exploration of tools is sensitive to specific tasks, and other factors must contribute to automatic action potentiation in the presence of tools.

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ACKNOWLEDGEMENTS

This research was funded by National Science Center (Poland) grant Maestro 2011/02/A/HS6/00174 awarded to Gregory Króliczak.

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