

Do Subliminally Presented Objects Potentiate Motor Responses?

Zissis Pappas, M.A.,¹ & Arien Mack, Ph.D.¹

Abstract ~ The dorsal visual stream has been implicated in visually guided motor behavior (Milner & Goodale, 1996). Can objects that are nondetectable (subliminal) activate the dorsal stream? Using the stimulus-response compatibility paradigm, a physical correspondence between stimulus and response yields faster reaction times (RTs), we briefly presented images of objects that afford a motor response: common graspable objects (Study 1; reaching and grasping) and indexical pointer finger (Study 2; orienting eye movement). When the orientation of the object and the response side were congruent, RTs were significantly faster than when they were incongruent even though the objects were not detected. This finding suggests that the dorsal stream processes information about the orientation of stimuli that are not consciously perceived and is consistent with the spared ability of blindsight patients.

1: Department of Psychology, Graduate Faculty, New School University, New York, USA

Address correspondence to Zissis Pappas, PappaZ01@newschool.edu

Introduction

Human vision is believed to consist of two functionally and anatomically distinct systems labeled the ventral and dorsal streams (Milner & Goodale, 1996; Mishkin, Ungerleider, & Macko, 1983). The ventral stream provides perception of form and is necessary for conscious perception, whereas the dorsal stream utilizes visual information for guiding movement thus allowing for fine motor adjustments (e.g., reaching and grasping an object, orienting eyes and head toward a stimulus). There is substantial evidence demonstrating that ventral stream damaged patients who are either cortically blind (Blindsight) or have severe impairment of form perception (visual form agnosia) can produce accurate motor responses to stimuli that are unidentified or unseen (Goodale, Milner, Jakobson, & Carey, 1991; Weiskrantz, Warrington, Sanders, & Marshall, 1974). Determining whether the spared ability of these patients is an artifact of their brain damage or evidence for two distinct visual systems that operate independent of each other requires a demonstration of blindsight in normal subjects (Ss). Here we present two studies that investigate whether a nondetectable (subliminal) stimulus activates the dorsal stream thereby producing motor priming for an unrelated task.

A few studies have found that a nondetectable stimulus can produce motor priming (Eimer & Schlaghecken, 2001; Schlaghecken & Eimer, 2000). In these studies, a subliminally presented prime stimulus such as a double arrow (<< or >>) is followed by a supraliminal presentation of either the same or opposite facing arrow. Ss responded to the orientation of the arrow with either their left or right index finger in a RT task. When the orientation of the prime and target arrows was congruent RTs were significantly faster than when the orientation of the arrows was incongruent. It is difficult, however, to argue this effect is solely due to motor priming since the prime and target

were sometimes the same stimulus. Therefore this effect may be the result of facilitated target identification on congruent trials rather than motor priming. Considering this problem, the question of whether dorsal stream activation by a nondetectable stimulus can produce motor priming has not been adequately demonstrated using healthy Ss.

A topic somewhat related to our question of whether the dorsal stream necessitates conscious perception is the issue of intentionality. If dorsal stream activation requires intention to generate visually guided movement then the stimulus must be detected (i.e., consciously perceived), but if activation occurs automatically the stimulus need not be consciously perceived. Tucker and Ellis (1998) found the dorsal stream is activated automatically without any intention to perform visually guided motor behavior, resulting in motor priming for an unrelated task. They presented images of common graspable objects (e.g., sauce pan) with their handles oriented to the left or right side. In a RT task Ss were instructed to press a button with either the left or right index fingers in response to the object being upright or inverted. When the handle was oriented to the same side as the response hand reactions times were significantly faster than when it was oriented to the opposite side. Since the position of the object's handle provides a potential for a reach and grasp response on the side (hand) it is closest to, it only relates to the response task by way of which side (finger) is responding. As a result, quicker responses are attributed to an automatic dorsal stream response to irrelevant orientation information. Using Gibson's (1979) notion of affordances, Tucker and Ellis (1998) argue that graspable objects automatically elicit a dorsal stream response because they afford reaching and grasping. This argument is compelling because there are many parallels between ecological approach to vision and the dorsal stream (Norman, 2002). Using a modified version of Tucker and Ellis' (1998) task as well as another task we investigated whether motor priming occurs for manual (study 1) and

oculomotor (study 2) responses to unrelated stimuli without conscious perception of the stimulus prime.

Study 1

If the orientation of an object's handle can activate the dorsal stream in the form of quicker RTs to an unrelated task when the object is supralimally presented, we questioned whether a subliminal presentation of the object would result in the same effect. Following Tucker and Ellis (1998) we presented graspable objects with the handle oriented to the left or right side. We strayed from their method, however, by subliminally presenting these images and asking the Ss respond to the position of a blue dot embedded in a subsequently presented pattern mask. We predicted that when the object's handle is oriented to the same side as the response finger (left or right index finger) RTs will be faster than when it is presented to the opposite side even though the objects were not detected.

Method

Participants

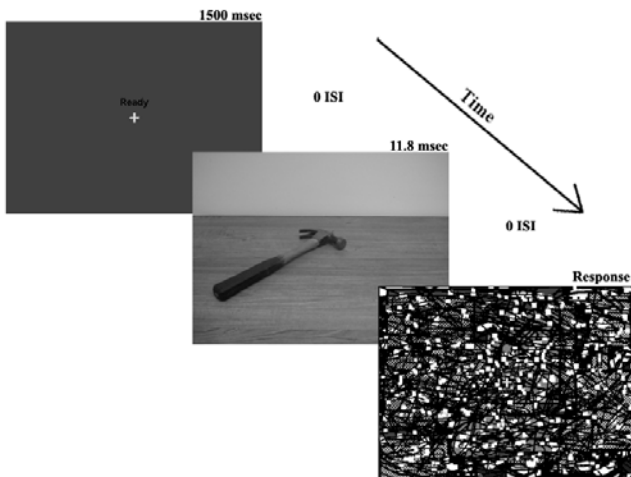
Twenty New School University students/employees with normal or corrected to normal vision.

Materials

Two hundred and eighty trials composed of 40 equally presented digital photographs of 20 common graspable objects (6°-24°) with their handles oriented 45° to the left or right side. Each photograph was presented for 11.8 milliseconds (ms) and followed by a pattern mask containing a blue dot slightly above or below the center of the screen (see figure 1a). For half of the trials the object's handle was oriented to the same side as the response hand (congruent trials), and on the other half it was oriented to the opposite side from the response hand (incongruent trials).

Procedure

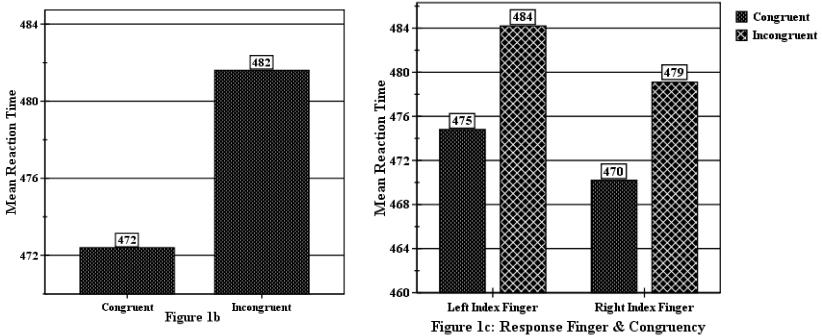
Participants were seated 45 cm in front a computer monitor with their heads in a chin rest and with both hands positioned 15 cm from the monitor on the far left and right sides of a keyboard. In one block of trials (140) Ss were instructed to quickly respond to the dot by pressing a button with their left index finger when the dot was in the upper position and with right index finger when it was in the lower position. In the other block of trials (140) this relationship was reversed. Ss were given 20 practice trials prior to each block. Following completion of the experiment Ss were asked if they had seen anything in addition to the blue dot and pattern mask to ensure the prime objects were not seen.



Results

RTs were significantly faster for congruent than incongruent responses, $t(19) = -3.65$, $p < .002$ (Fig. 1b). When object handle and response finger were congruent RTs were significantly faster

for the right index finger $t(19) = -2.46, p < .012$, and left index finger $t(19) = -2.81, p < .006$ (Fig. 1c). Following the RT task 5 Ss reported seeing one or more of the masked objects, only 2 of these Ss reported detecting more than one object (3 and 5). For the 15 Ss who did not detect any of the graspable objects, mean congruent and incongruent RTs were 474 ms and 483 ms respectively $t(19) = -3.13, p < .004$.



Discussion

We found clear evidence that subliminally presented graspable objects prime motor responses for an unrelated task. Since graspable objects afford a visually guided response that is mediated by specific dorsal stream modules (Milner & Goodale, 1996), we questioned whether the modules responsible for orienting the eyes toward a target is similarly affected by stimuli which afford an oculomotor response.

Study 2

In study 2 we subliminally presented an indexical pointing finger followed by a mask containing a red disc which appeared randomly on the far left or right side of the screen. Within the disc

was a small "E" or "F" which had to be fixated to be identified thus requiring a left or right saccade. We predict when the indexical pointing finger is facing the same side that the disc appears; calling for a saccade to that side, RTs will be faster than when the finger faces the opposite direction.

Method

Participants

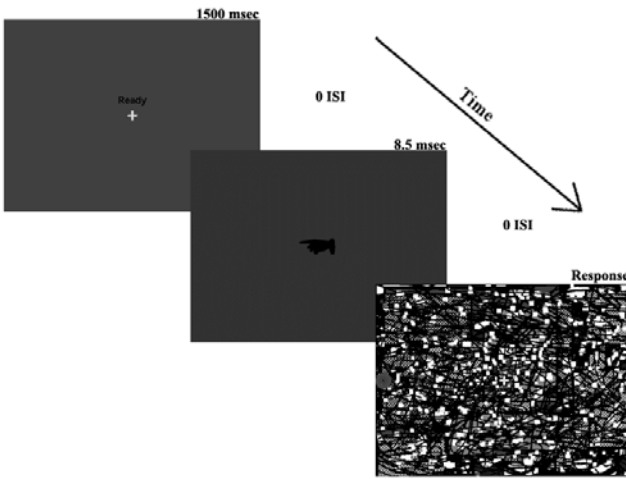
Twenty-four New School University students/employees with normal or corrected to normal vision.

Materials

Two hundred and eighty trials composed of 2 equally presented images of an indexical pointing finger (7.3°) facing the left or right side were presented for 8.75 ms followed by a pattern mask containing a red disc (3.4°) to the far left or right side of the screen (25.8° from the center). Within each disc was a small "E" or "F" ($.38^\circ$) which appeared equally on both sides. For half of the trials the indexical pointing finger faced the same side on which the disc appeared (congruent trials) and on the other half it faced the opposite side (incongruent trials).

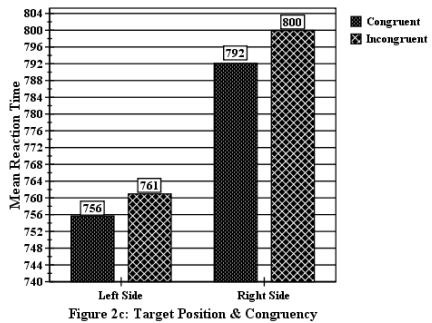
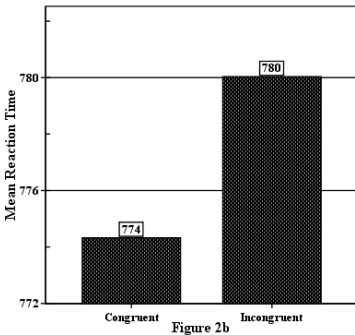
Procedure

Participants were seated 30 cm in front a computer monitor with their head in a restraint. On all trials Ss were instructed to keep their eyes on a fixation cross located in the center of the screen until they detected the appearance of the disc after which they were to quickly move their eyes to the disc's center and read aloud the letter. Ss were given 20 practice trials prior to this task. All responses were recorded by a voice key. Following completion of the experiment Ss were asked if they had seen anything in addition to the red disc and pattern mask to ensure the presentation was subliminal.



Results

When the finger pointed in the direction of the target's position RTs were significantly faster for right side responses $t(23) = -2.54, p < .009$, left side responses $t(23) = -1.82, p < .041$, and across both sides $t(23) = -2.94, p < .007$. Also, RTs to the disc on the left side were significantly faster than those on the right side for both congruent $t(23) = -4.24, p < .001$ and incongruent trials $t(23) = -5.01, p < .001$. This effect is consistent with findings that there is a left visual field advantage for spatial localization due to the



specialized processing of the right hemisphere (Jeeves & Dixon, 1970). None of the Ss reported seeing the indexical pointing finger.

Discussion

Again we found a nondetectable stimulus that affords a specific visuomotor response, which activates the dorsal stream resulting in motor priming for an unrelated task thus suggesting that conscious perception is not necessary for dorsal stream activation. There are however a number of caveats. Since we did not monitor eye movements, we can only assume eye movements were made to the target in order to identify the letter which could not be identified unless fixated. In addition, recent evidence demonstrates that the indexical pointing finger can elicit a reflexive attentional shift (Watanabe, 2002). Therefore our results could be due in part to an attentional shift as well as a facilitated motor response.

General Discussion

We presented two studies that demonstrate conscious perception of a stimulus is not necessary for it to activate the dorsal stream resulting in motor priming. We found that motor responses, pressing a key (Study 1) or reporting a target letter which required a fixating eye movement to be identified (Study 2), are facilitated by the orientation of nondetectable objects with motor affordances. This is consistent with the spared ability of blindsight patients, and with the hypothesis that the dorsal system controls sensorimotor behavior independent of the ventral system which is entailed in conscious perception. Further research should address how these objects, which afford a specific motor response, are identified by the dorsal stream and to what extent the ventral stream contributes to object identification for visually guided motor behavior.

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