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Does sensitivity in binary choice tasks depend on response modality? ☆

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ABSTRACT

In most models of vision, a stimulus is processed in a series of dedicated visual areas, leading to categorization of this stimulus, and possible decision, which subsequently may be mapped onto a motor-response. In these models, stimulus processing is thought to be independent of the response modality. However, in theories of event coding, common coding, and sensorimotor contingency, stimuli may be very specifically mapped onto certain motor-responses. Here, we compared performance in a shape localization task and used three different response modalities: manual, saccadic, and verbal. Meta-contrast masking was employed at various inter-stimulus intervals (ISI) to manipulate target visibility. Although we found major differences in reaction times for the three response modalities, accuracy remained at the same level for each response modality (and all ISIs). Our results support the view that stimulus-response (S-R) associations exist only for specific instances, such as reflexes or skills, but not for arbitrary S-R pairings.

1. Introduction

The very same stimuli can be mapped on very different motor responses, such as manual button presses, eye movements, or verbal responses. For example, when observers are asked to discriminate a square vs. a diamond, responses can be verbal "left"/"right" expressions, left/right button presses, or left/right eye movements. Most models assume, implicitly or explicitly, that stimuli are first processed in a sensory stage (e.g., photo-transduction at the retina), followed by a series of visual processing stages, leading to representation and categorization of the stimulus (Donders, 1969; Hubel & Wiesel, 1959; Marr, 1982; Poggio, 1984; Sternberg, 1969). Based on the categorization, a decision is made, and executed as a motor-response. Processing is fully independent of the type of the motor-response. Hence, accuracy for given stimuli and tasks is also independent of the type of the motor-response (as long as motor execution errors do not differ across response modalities).

In sharp contrast to these theories, sensori-motor contingency theories propose that certain stimuli may be specifically mapped onto certain motor-responses. For example, a skill like riding a bike comes with distinct sensori-motor contingencies. Similar to the Gibsonian approach (Gibson, 1966), the theory of event coding proposes that stimuli are coded by joint visuo-motor representations (e.g., Hommel & Müsseler, 2001). In the spirit of the behavioristic tradition, sometimes mental

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representations are entirely abandoned and identified with motor-actions (Nagel, Carl, Kringe, Märtin, & König, 2005; O'Regan & Noë, 2001). In such models, accuracy may differ for the same stimulus when motor responses are different. For example, for certain stimuli, eye movements may be the more "appropriate" motor-action than verbal responses, leading to superior performance (e.g., Hughes & Kelsey, 1984). Motor (e.g., saccadic) responses are faster than verbal response. They can be more automatic and may even be triggered by unconsciously perceived features. In line with this idea, performance in a near-threshold flash detection task was shown to be better when observers made a saccade than when they pressed a button (Hughes & Kelsey, 1984).

Accuracy may also strongly differ when stimuli are processed along different pathways, associated with different motor responses. For example, it is often assumed that a stimulus is processed both in the "conscious" ventral stream, specialized in shape and color analysis, and in the "unconscious" dorsal stream, being specialized in motor functions (Goodale, 2014; Goodale & Milner, 1992; Milner & Goodale, 1995; Ungerleider & Mishkin, 1982). Both streams may be differently sensitive to specific stimulus features. Indeed, patients with hemianopia are still able to make a saccade or to point to a target, but they cannot verbally report about this stimulus (Marcel, 1983; Perenin & Jeannerod, 1975; Poppel, Held, & Frost, 1973).

Experiments on motor priming also suggest that there are *transient* task dependent stimulus-response mappings (Jaśkowski, van der Lubbe, Schlotterbeck, & Verleger, 2002; Jáskowski, Skalska, & Verleger, 2003; Klotz & Neumann, 1999, etc.). In these studies, a prime stimulus (e.g., a rectangle on one side and a diamond on the other side) is followed by a slightly larger stimulus pair containing the target. Observers indicate the side on which the target (rectangle or diamond) was presented. Visibility of the prime increases when the ISI increases. Both with invisible and with visible primes, manual responses are commonly faster when the relevant shapes of the prime and the target are on the same side (i.e., congruent) as compared to when they occur on different sides (i.e., incongruent). This effect is commonly denoted as the priming effect and is often understood as being the consequence of activation of the corresponding motor response (e.g., see Klotz & Neumann, 1999). In line with the latter idea, other studies revealed that presentation of a prime already induced hand motor activation (e.g., Jaśkowski et al., 2002, 2003; Klotz, Heumann, Ansorge, & Neumann, 2007). Moreover, invisible primes may not only modulate responses to subsequent targets but may even elicit a wrong response (Jáskowski et al., 2003). Subliminal priming effects were not limited to hand motor reactions as they also facilitated verbal responses (Ansorge, Klotz, & Neumann, 1998; Eimer & Schlaghecken, 2001). Thus, motor priming is not limited to a specific response modality.

Here, we asked the question whether accuracy in a visual binary choice task depends on response modality.

2. General method

2.1. Participants

In total, 14 participants (ten males, four females; aged 18–28; mean 23.8) recruited from the local student population in Lausanne took part in the experiments (four in Exp. 1 and ten in Exp. 2). Participants were paid 20 CHF per hour. All observers had normal or corrected-to-normal visual acuity as determined by a computerized visual acuity test (Freiburg Visual Acuity Test; Bach, 1996). To participate in the experiment, participants had to reach a value of 1.0 (corresponding to a Snellen fraction of 20/20) for at least one eye. The experiment was conducted with the informed and written consent of each participant. All procedures complied with the Declaration of Helsinki and were approved by the local ethics committee.

2.2. Apparatus

Stimuli were presented on a Philips 201B4 CRT monitor driven by a standard accelerated graphic card refreshed at 75 Hz (Exp. 1) or on an ASUS VG248QE LCD monitor with 120 Hz refreshed rate (Exp. 2). Participants were seated in a room dimly illuminated by a background light of about 0.5 lx. The observation distance was 90 cm. Participants were restrained by a chinrest. For eye movement control, we used the iView X-HiSpeed eye tracker from SensoMotoric Instruments (SMI), which was set up for binocular mode with a 500 Hz sampling frequency. Signals of both eyes were averaged in order to reduce noise. Verbal responses were registered by a Hama Stereo Directional Microphone (RMZ-14).

2.3. Stimuli and procedure

Trials started with a fixation dot presented for 1 s. Subsequently, a square was presented for 13 ms (Exp. 1) or 17 ms (Exp. 2) pseudo-randomly either to the left or right from the central fixation dot at 4° of eccentricity. A diamond was simultaneously presented at the opposite side (Fig. 1). The square and diamond had an equal width of 0.8°. After a variable ISI, a mask was presented at the square and diamond location for 100 ms. The inner masks contours abutted the contours of the square and diamond. The mask size was $1° \times 1°$. All stimuli were black outlines and were presented on a gray background (Exp. 1: 18 cd/m^2, Exp. 2: 52 cd/m^2).

Half of the participants were instructed to indicate as accurately as possible whether the square was on the left or on the right side, while the other half of the participants had to indicate the side of the diamond. In three different sessions, responses were given with either the left or the right hand, by making a saccade to the left or right, or with verbal responses by saying "left" or "right". A trial ended after the participant's response or after a maximal time interval of 5 s. The order of