Interactions between perception and action in a reaction task with overlapping S-R assignments

Received: 11 July 2000 / Accepted: 4 March 2001

Abstract We have used a novel task to study relationships between perception and action. Four experiments studied stimulus-response (S-R) relationships under conditions in which stimuli and responses were functionally unrelated (i.e., not assigned to each other by instruction) and merely overlapped in time. On each trial, participants carried out movements on a graphic tablet while observing motions displayed on a computer screen. The movement on trial \( n \) was specified by the motion observed on the previous trial \( n-1 \), whereas the motion observed on trial \( n \) specified the movement to be performed on trial \( n+1 \). Results showed that stimulus motion had a contrast-like impact on response movement. Watching a small motion while performing a medium-sized movement increased movement size, whereas watching a large motion led to a decrease (Experiment 1). Further experiments showed that the contrast pattern was not affected by the mode of motion presentation (Experiment 2), or by the interval between motion and movement execution (Experiment 3). Contrast was also observed in the reverse direction, i.e., from action to perception (Experiment 4). We propose that the contrast effect is due to a mechanism for selective code modification. This mechanism acts to increase the distinctiveness of simultaneously activated perception and action codes in a common representational domain.

Introduction

The present study investigates the relationship between perception and action control using a new paradigm. Consider a task in which a stimulus is presented while a response is executed. Both, however, refer to different S-R assignments and merely overlap in time: while a response (assigned to a previous stimulus) is being performed, a new stimulus (assigned to a different, upcoming response) is presented and needs to be encoded.

At first glance, this seems a somewhat artificial situation, and most research on the perception-action relationship so far has focused on studies and theories dealing with the translation of a stimulus into an assigned response, where stimulus and response belong to the same assignment (e.g., Greenwald, 1970, 1972; Klapp, Porter-Graham, & Hoijfeld, 1991; Kornblum, Hasbroucq, & Osman, 1990; Simon & Rudell, 1967). For example, stage models (e.g., Meulenbroek & Van Galen, 1988; Sanders, 1980, 1990; Spijkers & Walter, 1985) postulate a response-selection stage where the outcome of the stimulus processing is linked to an assigned response. However, considering that most of our daily activities involve doing more than one thing at a time, it seems appropriate to study the relationship between perception and action with a task where stimulus and response belong to different assignments.

Classical models of S-R translation do not speak to a situation like this, where the selection of the upcoming response is not under control of the presently given stimulus. Still, one obvious possibility is that, in tasks like these, response performance is affected by stimulus properties in the same way as in standard choice-reaction tasks. For instance, feature overlap between stimuli and responses could be likewise beneficial across S-R assignments as it has been shown to be in numerous studies with feature overlap within assignments (cf., Hasbroucq & Guird, 1991; Kornblum et al., 1990; O’Leary & Barber, 1993). However, another possibility is that the impact of the same factor is different within and across assignments. When stimuli and responses belong to two different assignments, they need to be kept separate from each other – or even protected against each other – perhaps to the effect that feature overlap...
between them is now detrimental rather than beneficial. Indeed, this result was what we expected, based on the notion of common-coding between perception and action (Prinz, 1990; Hommel, Müsseler, Aschersleben, & Prinz, in press; for details, see below).

We developed a Serial Overlapping Response Task (SORT), which consists of a sequence of stimuli and a sequence of responses. However, the special feature of this task is that each response is assigned to the stimulus presented on the previous trial. During response execution, a new stimulus is presented that has to be responded to on the subsequent trial. Hence, on each trial, participants have to do two things at the same time: encode the stimulus being presented (for later responding) and respond to the stimulus presented on the previous trial. This task entails overlap in the sense that two independent S-R assignments overlap on each trial.

Importantly, we were not interested in unspecific interference resulting from the fact that two tasks were performed at the same time and thus compete for processing capacity (e.g., Heuer & Wing, 1984; Pashler, 1993). Instead, we aimed at investigating how specific stimuli would interfere with specific responses. The classical literature on S-R compatibility studies the impact of similarity, or feature overlap, within S-R assignments (e.g., Greenwald, 1970, 1972; Hasbroucq & Guiard, 1991; Klapp et al., 1991; Kornblum et al., 1990; O’Leary & Barber, 1993). Accordingly, SORT was designed to study the impact of the same factor across S-R assignments.

Logically, there are three possible outcomes of the S-R similarity manipulation in the SORT. First, there may be no specific S-R effects at all. In this case, stimuli would influence responses only if the two belong to the same S-R assignment. For instance, most serial stage models attribute S-R compatibility effects to the stage of response selection, or S-R translation. Since no such translation is required between the actual stimulus and the actual response, no effects may be observed.

Second, S-R effects across S-R assignments may occur, which would fit to a view taken by the common coding approach of perception and action (Prinz, 1990, 1997; see also Hommel, 1997; Hommel, Müsseler, Aschersleben, & Prinz, in press). According to this approach, stimulus and response rely on similar cognitive representations. Unlike traditional models, the common-coding approach does not restrict S-R interactions to a single stage in the processing of information. Rather, it postulates a representational domain for both stimulus and response codes where processing and programming can interact whenever stimulus and response are processed simultaneously, i.e., also in the absence of an assigned relationship between the stimulus and the response involved – just as realized in the SORT.

What form, then, might the effects take? As a second possible outcome of the SORT, the stimulus might ‘at-

‘tract’ the simultaneously executed response, leading to an assimilation of the response to the features of the ongoing stimulus motion. In fact, in studies on S-R relationships within assignments, similarity between stimulus and response typically leads to facilitation of the assigned response (e.g., Fitti & Seger, 1953; Greenwald, 1970, 1972; Klapp et al., 1991; Kornblum et al., 1990; Simon & Rudell 1967).

However, as a third possible outcome of the SORT, the nature of the assignment may play an important role and modulate the nature of the stimulus-induced response activation. Unlike standard S-R tasks, in which the response is usually coupled functionally (assigned) to the stimulus within the same trial (usually by instruction), SORT is quite different in that it requires a decoupling of the ongoing response from the simultaneously presented stimulus. In fact, the task requires simultaneous processing of two S-R assignments, which need to be kept separate. Therefore, any tendencies toward stimulus-induced response activation across assignments might even have to be suppressed if both subtasks are to be performed equally well. Under these circumstances, rather than facilitation, one could expect some form of mutual suppression of stimulus and response processing within the SORT paradigm. Some empirical evidence has indeed been found showing that similarity may impede rather than facilitate processing across assignments (e.g., Müsseler & Hommel, 1997; Wühr & Müsseler, in press).

**Experiment 1**

The first experiment tested whether any specific S-R effects are found in the SORT paradigm, i.e., whether a stimulus would directly influence the parameters of a simultaneously executed movement across S-R assignments. Again, we were not interested in unspecific interference effects owing to two simultaneous tasks (Heuer & Wing, 1984), but in specific interference effects which may result from the similarity between stimuli and responses that are processed simultaneously.

Figure 1 summarizes the logic of SORT as indicated above. Stimuli and responses were assigned across trials such that the response to each stimulus had to be performed on the subsequent trial, while the next stimulus was being presented. Stimuli and responses consisted of two-dimensional sinusoidal movements that differed in amplitude size and velocity. Participants watched a stimulus motion on a screen and were instructed to copy it on a graphic tablet with a stylus during the subsequent trial. On a typical trial, they had to encode the presented stimulus, memorize it shortly, prepare the assigned response, and execute it while the next stimulus was being presented. Within this paradigm, movement execution was compared under three conditions: when the amplitude of the simultaneously presented stimulus was (a) smaller than, (b) the same size as, and (c) larger than the amplitude of the executed movement. We were also

---

1Note that none of the stage theories actually make any predictions on what would happen across S-R assignments.