

Trajectory control in targeted force impulses

V. Gradual specification of response amplitude

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Summary. This study was undertaken in order to determine the time course of the process by which information derived from a visual target is used to accurately set the amplitude of a simple motor response. We refer to this process as response specification. Separate auditory and visual cues were given to the subjects in order to independently control the moment of response initiation and the time available for processing amplitude information from the target. Six subjects initiated impulses of isometric force in synchrony with the last of predictable series of regular tones. Response amplitudes were to match one of three visual target steps occurring at random times between 0 and 400 ms before the response-synchronizing tone. Using these separate auditory and visual cues, we were able to systematically vary the time interval between target presentation and response onset, termed here Stimulus-Response or S-R interval. Target steps were presented in blocks of either predictable (simple condition) or unpredictable (choice condition) amplitudes. The peak forces and the peaks of their time derivatives were analyzed to determine how subjects achieved accuracy under the different conditions and at different S-R intervals. The trajectories of responses produced in the simple condition were independent of the S-R interval. In contrast, when targets were presented in unpredictable order, the distribution of the peak forces of the subjects' responses depended on the S-R interval. At short S-R intervals (< 125 ms), subjects made responses whose peak forces were distributed around the center of the range of target steps. These responses formed

a unimodal, but broad distribution which was independent of actual target amplitude. With increasing S-R interval (> 125 ms), the distributions of peak forces gradually shifted toward the correct target amplitudes, with the means reaching the appropriate amplitudes at S-R intervals of 250–400 ms. At S-R intervals comparable to a reaction time, the range of peak forces was constricted to a similar extent as previously observed in a reaction time task (Hening et al. 1988). We found that the gradual improvement of accuracy was not achieved through changes in trajectory control: at all S-R intervals, subjects utilized a pulse-height control policy (Gordon and Ghez 1987a). Different peak forces were achieved by varying the rate of rise of force, while force rise time was held relatively invariant. We did find, however, that within the constraints imposed by rise time regulation, compensatory adjustments to the force trajectories (Gordon and Ghez 1987b) were greatest during the period of specification. We conclude that (1) subjects can initiate their responses independent of the degree of specification achieved and that the normal process of specification of amplitude begins earlier and continues longer than the latency of responses in a reaction time task; (2) before target presentation, subjects prepare a default response whose amplitude is biased by prior experience with the targets presented in the task. We hypothesize that the central mechanisms that specify response amplitude do so by a progressive adjustment of the default parameters.

Key words: Humans – Trajectory control – Isometric force – Motor program – Reaction time – Information processing

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