

Trajectory control in targeted force impulses

VI. Independent specification of response amplitude and direction

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Summary. The preceding study of this series (Hening, Favilla and Ghez 1988) examined the time course of the processes by which human subjects use information from a target to set the amplitude of an impulse of isometric elbow force. In that study, subjects were provided with separate cues to time response initiation and to inform them of the required amplitude of the response. When the time between target presentation and response initiation was too brief for them to incorporate information from the target, subjects produced default responses whose amplitudes reflected their prior experience. At longer latencies, subjects specified response amplitude with a gradual time course, starting earlier and ending later than an average reaction time. The present study now examines how two distinct response features, amplitude and direction, are specified following presentation of a target. We sought to answer three main questions. What are the features of responses that are produced before target information is available? Are direction and amplitude specified serially or in parallel? Does the specification of one response feature interfere with the specification of the other? Six normal subjects were studied. They were trained to initiate impulses of isometric elbow force in synchrony with the last of a predictable series of regular tones. The amplitudes and directions were to match those of visual targets requiring flexions or extensions with one of three amplitudes. The targets were presented at random times (0–400 ms) before the last tone. Target directions and amplitudes were either predictable (*simple* condition) or unpredictable (*choice* condition). In the

simple condition, response amplitudes and directions were independent of the interval between target presentation and response onset (S-R interval). In the *choice* condition, both amplitude and direction varied with the S-R interval. At short S-R intervals (< 100 ms), the direction of the subjects' responses was not related to that of the target. The amplitudes of the responses were near the centers of the two target ranges. With increasing S-R intervals, the proportion of correct direction responses gradually increased. Over the same range of S-R intervals, the amplitudes of both right and wrong direction responses to the different targets separated and converged on their respective target amplitudes. Specification of both direction and amplitude was complete at S-R intervals greater than 300 ms. The time course of amplitude specification in this bidirectional paradigm was prolonged over that in a paradigm where response direction was predictable. As in our previous reports, subjects varied response amplitude by adjusting the time derivatives of force rather than force rise time. Response trajectories were similar for flexor, extensor, right and wrong direction responses. We conclude *first*, that the amplitudes of impulsive responses to unpredictable targets are specified from an initial default value even when both amplitude and direction are unpredictable; *second*, the amplitude and direction of such response are specified gradually by separate processing channels operating in parallel; *third*, the processing of the two response features is not, however, fully independent. It is suggested that the two processes share a common neural resource.

Key words: Human subjects – Trajectory formation – Isometric – Accuracy – Reaction time – Targeted responses – Sensorimotor processing

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