

## Trajectory control in targeted force impulses

### IV. Influences of choice, prior experience and urgency

W. Hening\*, D. Vicario\*\*, and C. Ghez

Center for Neurobiology and Behavior, New York State Psychiatric Institute, College of Physicians and Surgeons, Columbia University, New York, NY 10032, USA

**Summary.** The present study examines the influences of target predictability, level of practice and response urgency upon the latency and trajectory of a simple motor response. This response is an impulse of isometric force produced by the index finger and aimed to match a step change in a visual target. As expected (Welford 1980), the responses of naive subjects responding as soon as possible after target presentation were initiated at longer latencies when the target steps were of unpredictable amplitudes (choice condition) than when their amplitudes were all the same (simple condition). This choice effect on response latency diminished progressively with practice and eventually disappeared. The trajectories of urgently produced choice responses, however, differed from those of simple responses, and this difference was not reduced by practice. Choice trajectories were more variable and showed a systematic distortion in scaling: response amplitudes exhibited a central tendency bias, or range effect. When targets were equiprobable, responses were biased towards the middle sized target while responses aimed at targets of unequal probability were biased towards the most probable. This effect was independent of the absolute amplitudes of the responses required and was not associated with deviations from the pulse height control policy (Gordon and Ghez 1987a) that human subjects use to vary the amplitude of force impulses. The distortion in scaling and the increased variability of responses aimed at individual targets were markedly reduced when urgency was relaxed and subjects could respond when ready. Then, both simple and choice responses were proportionally scaled to the target,

but choice responses were initiated at longer latencies. The changes in trajectory of urgent responses suggests that their inaccuracy occurs because the subjects initiate their responses before the specification of amplitude is complete. The central tendency bias of such incompletely specified responses suggests further that, prior to target presentation, subjects prepare a default response reflecting their expectations. This default may then be modified by information obtained from the target in a process that lasts longer than a minimal reaction time.

**Key words:** Humans – Trajectory control – Motor programs – Reaction time – Isometric force – Accuracy

### Introduction

The present series of studies attempts to characterize the processes underlying the achievement of accuracy by human subjects in a simple motor task. The task required subjects to produce a transient isometric impulse of force whose amplitude was to match that of a visual target. We have chosen this response, which is too brief to be visually corrected, as a model system to study the operation of central programming mechanisms. The isometric conditions minimize both the contributions of proprioceptive feedback and the complex biomechanical constraints inherent in the control of limb displacements (Ghez and Gordon 1987). Our initial studies focused first on the nature of the control signals acting on agonists and antagonists to produce different trajectory profiles (Ghez and Gordon 1987). We then analysed the strategies used by subjects to accurately match the amplitude of the force impulses to visual targets requiring impulses of different amplitudes. We found that subjects consistently adopt a pulse height control

Present addresses: \*Department of Neurology, Lyons Veterans Administration Medical Center, Lyons, NJ 07939, USA

\*\* The Rockefeller University, New York, NY 10021, USA

Offprint requests to: C. Ghez, Center for Neurobiology and Behavior, 722 W. 168th Street, New York, NY 10032, USA

