Spatial visuo-motor compatibility and manual control in a tracking task

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Abstract

We asked how spatial compatibility between target and tracking directions affects tracking performance. The subject's task was to keep a small target within the center of a 0.6-deg window defined by two parallel bars. The angular correspon-dence between target and tracking directions varied in steps of 45 deg from compatible (0 deg) to incompatible (180 deg) and intermediate (perpendicular and diagonal) arrangements. In Experiment I, the trajectory of the target had a constant orientation while the orientation of the tracking rail was varied. In Experiment II, the tracking rail remained constant while the orientation of the visual display was varied. In both experiments, tracking performance (time on target, root-mean-square error) was found to vary with angular visuo-motor compatibility, with a performance minimum at 180 deg in Experiment I and at 225 deg in Experiment II. This effect was strongest for untrained subjects but persisted even after practice.

Introduction

The principle of compatibility was originally introduced in the context of human factors during World War II in an effort to enhance signal detection. A visual display was added to an auditory display and, interestingly enough, research on this dual-modality display showed that it was not always advantageous to have additional visual information. Detection thresholds typically increased when the display provided "incompatible" attributes. This occurred, for instance, when the auditory stimulus varied in amplitude, while the visual signal varied in spatial position. Compatibility would have required that both signals varied in, for example, intensity in a congruent way. This result, which was first presented in 1951 by Arnold Small in England at a meeting of the Ergonomics Research Society, attracted the attention of Paul Fitts who described the compatibility principle as "a landmark of great significance with broad applicability" (Small, 1990).

During the next few years, Fitts and his co-workers applied the compatibility principle not only to stimulus-stimulus (S-S) pairings but also to stimulus-response (S-R) and to response-response (R-R) compatibility. Today, relationships between stimulus and response properties dominate this area, especially in ergonomics.

Most studies on S-R compatibility address problems such as spatial coding, human information processing and motor performance, man-machine interaction,