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Effects of aging on pointing movements under restricted visual feedback conditions

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ABSTRACT

The goal of this study was to investigate the effects of aging on pointing movements under restricted visual feedback of hand movement and target location. Fifteen young subjects and fifteen elderly subjects performed pointing movements under four restricted visual feedback conditions that included full visual feedback of hand movement and target location (FV), no visual feedback of hand movement and target location condition (NV), no visual feedback of hand movement (NM) and no visual feedback of target location (NT). This study suggested that Fitts' law applied for pointing movements of the elderly adults under different visual restriction conditions. Moreover, significant main effect of aging on movement times has been found in all four tasks. The peripheral and central changes may be the key factors for these different characteristics. Furthermore, no significant main effects of age on the mean accuracy rate under condition of restricted visual feedback were found. The present study suggested that the elderly subjects made a very similar use of the available sensory information as young subjects under restricted visual feedback conditions. In addition, during the pointing movement, information about the

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hand's movement was more useful than information about the target location for young and elderly subjects.

1. Introduction

Many studies have researched the concept of the speed–accuracy trade-offs by using goal-directed pointing movement (Meyer, Abrams, Kornblum, Wright, & Keith Smith, 1988; Pelisson, Prablanc, Goodale, & Jeannerod, 1986; Welford, 1988). The predominant model employed in researching the speed-accuracy trade-offs was proposed by Fitts (1954), who was the first to propose a formal relationship between movement time (*MT*) and the index of difficulty (*ID*), which is $MT = a + b * ID$ (where *a* and *b* are empirical constants; $ID = \log2(2A/W)$; *W*: the width of the target; and *A*: the distance from the starting point to the target). The *ID*–*MT* linear relationship was called Fitts' law. The *y*-intercept of the linear regression is an important parameter in Fitts' law. Ideally, the *y*-intercept should be zero for the intuitive reason that a movement rated at $ID = 0$ should not take any time to complete. However, when Fitts' equation was first proposed, Fitts' has also suggested different views that the *y*-intercept should not be zero or less than zero movement time owing to the natural variability of human performance. (Fitts & Peterson, 1964; Fitts & Radford, 1966). There is no consensus on the source of the non-zero *y*-intercept might be due to none of the existing explanations is satisfactory (for review, see Soukoreff & MacKenzie, 2004). Moreover, the slope of the regression line is also an important parameter in Fitts' law. Zhai (2004) shows that the slope reciprocal yields values of 8.197 bps through analyzing all data from Fitts (1954) paper. However, the previous researches have also presented the value of the slope of the regression line in their discrete pointing tasks which were smaller than that observed in the classical Fitts' task (Annett, Golby, & Kay, 1958; Medina, Jax, & Coslett, 2009; Wu, Yang, & Honda, 2010). Since the *ID*–*MT* linear relationship was first proposed, numerous researches regarded the intercept and the slope of linear regression as important parameters to test whether Fitts' law apply for their movement conditions (for review, see Soukoreff & MacKenzie, 2004). Since Fitt' law firstly confirmed the applicability of rapid-movement, it has been confirmed to hold for rotational movements, prehension movement, and foot movements, except for imagined pointing movements (Bootsma, Marteniuk, MacKenzie, & Zaal, 1994; Grosjean, Shiffrar, & Knoblich, 2007; Hoffmann, 1991; Personnier, Ballay, & Papaxanthis, 2010; Personnier, Kubicki, Laroche, & Papaxanthis, 2010; Skoura, Papaxanthis, Vinter, & Pozzo, 2005; Skoura, Personnier, Vinter, Pozzo, & Papaxanthis, 2008). The conditions of these rapid-aiming movement have also extended constantly from full vision conditions to restricted visual feedback conditions of hand movement and target location (Carlton, 1981; Haaland, Harrington, & Grice, 1993; Sarlegna et al., 2003; Wu et al., 2010).

As a common Fitts' task, the goal-directed pointing movements toward visual targets are controlled by the processing information relative to the target location and hand's movement (Prablanc, Echallier, Komilis, & Jeannerod, 1979). It has been consistently found that combined visual and proprioceptive encoding of the initial hand position improves the ability of the young adults to plan goal-directed movements compared to proprioceptive encoding alone (Desmurget, Rossetti, Jordan, Meckler, & Prablanc, 1997). Moreover, the young subjects are generally more accurate when they can see the target throughout the arm movement than when vision of the target is extinguished near movement onset (Pelisson et al., 1986). This suggests that visual information is continuously processed to update the internal representation of target location in order to obtain higher movement accuracy. In addition, there are some researches attempt to compare the contributions of visual information of hand and target position in goal-directed movement. Carlton (1981) found that movement accuracy of the young adults decreased to a greater extent when vision of the hand was withdrawn than when vision of the target was precluded at the arm movement onset. However, these results were not confirmed by Sarlegna et al. (2003) who found visual information relative to hand position may be less contributive than target location in online control of the goal-directed arm movement.