143 - CONTROL OF FAST AND ACCURATE MOVEMENTS

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INTRODUCTION

The control of fast and accurate movements is traditionally explained by the Fitts' law (1954). This author showed an inverse relationship between speed and accuracy. Therefore, as greater the demand of the accuracy in a motor task is, lower is the speed of the movement observed (greater time of movement) or vice versa. Fitts (1954) showed, in three experiments, by manipulating the target widths (A) and distances (D), that the movement time (TM) is a linear function of the index of difficulty (ID), this last one has been expressed by the following equation: ID=log2 (2D/A). Thereby, the ID increase generates a proportional increase in TM. Several models of motor control were explored to explain this inverse relationship between speed and accuracy.

The models that attempted to explain the origin of the inverse relationship between speed and accuracy were based on: the use of feedback (WOODWORTH, 1899), noise generation (MEYER; SMITH; WRIGHT, 1982; SCHMIDT et al., 1979), limited capacity for information processing (FITTS, 1954), modulation between the acceleration and deceleration phase of movements (TEIXEIRA, 2000), and organization of the agonistics-antagonistics synergies of the movement (PLAMONDON; ALIMI, 1997). However, these models were unable to explain the fact that a movement can often present both, great speed and accuracy. A possible explanation would be based on the hypothesis of independent dimensions (components) of speed-accuracy (OKAZAKI, 2009).

This hypothesis suggests that, when the speed generation occurs predominantly in one spatial dimension and accuracy in another, the movement could be both fast and accurate. Since, the velocity generated would be the result of different sources of constraint on the accuracy found during movement. Therefore, specific velocity magnitudes would be generated and it would result in specific variability of the movement, mainly in relation to the spatial dimension where the sources of constraints occur. Within this scope, it was analyzed the hypothesis of the independent components of speed-accuracy as a possible alternative to understand the movement control regulation for fast and accurate movements.

METHODS

Participants

The sample was composed by 12 right-handed college students, aged between 23 years (DP=2,67) from both sex. Before beginning the test, the participants assigned a free consent term to participate in the study. The experimental procedures were approved by the local university`s Ethical Commit of Research (Protocol n. 215/10, Title Page n. 368584, CAAE n. 0197.0.268.000-10).

Equipment and task

The participants performed a task of moving the mouse cursor, using a stylus and a digital table (C3 Tech), aiming to reach a spatial target. The target widths (10, 20 and 40 u.m) and the distance in which there was change in the direction of the movement were manipulated through the Spatial Constraint Task software (v.1.0.;OKAZAKI, 2011). The index of difficulty of the task was calculated using the distance (D) between the targets and the target widths (A), in accordance to the original equation proposed by Fitts (1954): ID = log2(2xD/A).

Procedures

The beginning of the task was determined by pressing the stylus tip on the digital table over the first target and the task finished after the cursor courses all the area bounded by the software until pressing the stylus tip on the second target. Participants were instructed to perform the task as fast and more accurate as possible.

Changes in direction of the trajectory were used in portions of 66% (condition A), 33% (condition B), and 0% (condition C, without change in the direction). In other words, an horizontal linear movement was performed until this portion of the track were coursed then, there was a change in the movement direction perpendicularly upward until the second target (figure 1).



Figure1. Schematic representation of the experimental conditions for the direction changes in the track trajectory: A (66%), B (33%), and C (0%).

The data's descriptive analysis was performed by mean and standard deviation. The comparison between the different conditions was performed by ANOVA test with two factors, 3 (ID) x 3 (Direction), both with repeated measures. For the following comparisons, it was used the Tukey test. Statistical significance was set at 5% (P<0,05).

RESULTS

Results showed main effect for Direction factor (F2,22=93,13; P<0,01), ID factor (F2,22=15,71; P<0,01), and for the interaction between Direction and ID (F4,44=4,11; P<0,01). TM in ID 3,39 bits (M=2,09s; SD=1,27) was lower in comparison to ID

4,39 bits (M=2,61s; SD=1,23) and ID 5,39 bits (M=3,72s; SD=1,48) in A condition (P<0,05). TM in ID 3,39 bits was different between conditions (P<0,05), in which there was lower TM in C condition (M=1,71s; SD=0,98), followed by greater TM in B condition (M=1,93s; SD=1,08) and with even greater TM for A condition (M=2,09s; SD=1,27). TM with ID 4,39 bits also showed difference between conditions (P<0,05), in which, there was lower TM for C condition (M=2,43s; SD=1,32), followed by B condition (M=2,59s; SD=1,23) and with greater TM for A condition (M=2,61s; SD=1,23). It was also verified difference for ID 5,39 bits between conditions (P<0,05), in which there was lower TM for C condition (M=2,89s; SD=1,14), followed by B condition (M=3,57s; SD=1,36), and with greater TM for A condition (M=3,72s; SD=1,48).

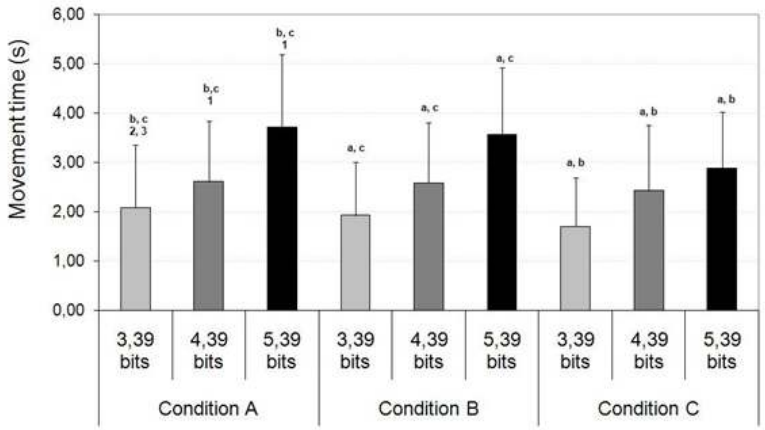


Figure 2. Movement time (TM) for each direction change (A, B, and C), in function of the Index of Difficulty for the task (ID). Legend: significant difference (P<0,05) compared to the same ID between aA condition, bB Condition, and cC Condition; and for the comparison between different IDs in the same condition: 1ID 3,39 bits, 2ID4,39 bits, and 3ID 5,39 bits.

DISCUSSION

The present study aimed to analyze the independent dimensions of speed and accuracy as a possible alternative to understand the control of fast and accurate movement. The results of the present study pointed to a greater constraint over TM when there was change in movement direction. Thereby, the speed and accuracy components were not controlled independently. This absent of support for the hypothesis of independent dimensions was explained by the greater constraint provided by conditions with directional changes and by the fact that the software linear movements was resulted by the joint angular actions from upper limbs.

The particular characteristics of the conditions A and B, with the velocity generation happening predominantly in one spatial dimension (x or horizontal axis) and the accuracy constraint in other dimension (y or vertical axis) was not sufficient to confirm the hypothesis of the independence between speed and accuracy components for the movement control (OKAZAKI, 2009). Thus, the constraint that occurred over the speed would refer only to the spatial dimension in which it was performed (x axis, that in A condition represented 66% of the total track of the task and in B condition represented 33%). Whereas, accuracy constraint (y axis) occurred in other spatial dimension perpendicular to the dimension that the speed was generated. However, in C condition (speed and accuracy in the same axis), similar to the simpler tasks (i.e., unidimensional ones) analyzed in the paradigm of inverse relationship between speed and accuracy (FITTS, 1954; OKAZAKI et al., 2008b; PEREIRA; OKAZAKI, 2008), it was verified lower movement of time in comparison to the A and B conditions with changes of direction in all IDs. Therefore, the manipulation of the spatial constraints dimension (such as the task analyzed in the present study), the speed and accuracy components were not controlled independently.

The A and B conditions, with changes in direction, showed greater time movement, this result can be explained because the changes in direction caused constraints generating two deceleration phases. In other words, one phase of deceleration in the change of direction e another phase of deceleration in which the stylus needed to reach the target (accuracy), consequently, providing an increase on the time movement. For A condition, with change direction in portion of 66% of the total track, it was verified greater movement time in all IDs in comparison to the other conditions. The portion of 66% (x axis) in A condition, in which there was the greatest velocity generation, was not sufficient to compensate the accuracy phase in the final portion of 33% of the track (y axis) that was prejudiced by a second deceleration phase and by the feedback decrease. Therefore, the greater acceleration phase (x axis) for the development of speed resulted in lower possibility of adjustments in the deceleration phase (y axis) of the movement in A condition.

CONCLUSION

It was verified greater TM dueto the increase in ID, as pointed by Fitts (1954). However, when the linear component of speed development (x axis) happened in a different spatial dimension of accuracy control (y axis), A and B conditions with change in direction, showed greater TM. Such results provided no data in favor of the hypothesis of independent components. More studies were suggested to test the hypothesis of the independent components in other motor skills.

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CONTROL OF FAST AND ACCURATE MOVEMENTS

ABSTRACT

The present study analyzed the hypothesis of the independent components of speed and accuracy to control fast and accurate movements. Twelve college students (right-handed) with mean age of 23 years old (SD=2,67) participated in the study. The task was performed moving a computer cursor controlled by a stylus and a digital table aiming spatial targets. It was manipulated the distance between targets, targets widths, and the direction to be tracked by the cursor. It was verified lower time movement in the condition in which there was no direction change, in comparison to the other conditions (P<0,05). Therefore, it was not provided evidence to support the hypothesis of the independence between speed-accuracy. Such results were explained by the great constraint provided in the conditions with change of direction and by the fact that linear movements performed in the software were the result of joint angular actions from the upper limbs.

KEY-WORDS: spatial targets; speed-accuracy; Fitts' law.

CONTRÔLE DES MOUVEMENTS VITESSE ET PRÉCIS

RÉSUMÉ

Cette étude a examiné l'hypothèse d'indépendance des composants de précision les mouvements de contrôle de vitesse rapide et précise. Douze étudiants de l'université pour droitier avec l'âge moyen de 23 ans (SD=2,67) ont participé à l'étude. La tâche consistait à déplacer un curseur de l'ordinateur contrôlé par un stylet et une tablette dans l'espace cible. Nous manipulés à distance entre les cibles, les tailles cibles et la direction à être parcourue par le curseur. On a constaté moins de temps pour passer à la condition qu'aucun changement de direction, en comparaison aux autres conditions (P<0,05). Ainsi, pas fourni de preuve de l'hypothèse d'indépendance des composants vitesse de précision. Ces résultats ont été expliqués par la plus grande restriction prévue dans les conditions changent et avec la direction des mouvements linéaires, car le logiciel est une suite d'actions de joints angulaires des membres supérieurs.

MOTS-CLÉS: Les cibles spatiales; la rapidité-précision; la loi de Fitts.

CONTROL DE MOVIMIENTOS RÁPIDOS Y PRECISOS

RESUMEN

El presente estudio analizó la hipótesis de los componentes independientes velocidad-precisión en el control de movimientos rápidos y precisos. Doce universitarios diestros con edad promedio de 23 años (DP=2.67) participaron del estudio. Se realizó la tarea de mover un cursor de computador controlado por un ratón y una mesa digitalizadora en dirección a objetivos con posiciones predeterminadas, en los cuales se manipuló la distancia entre ellos, el tamaño de los mismos y la distancia a ser recorrida por el cursor. Se verificó menor tiempo de movimiento en la condición en la que no hubo cambio de dirección en comparación a las otras condiciones. (P<0.05). Así no fueron constatados indicios a favor de la hipótesis de los componentes independientes velocidad-precisión. Tales resultados se explicaron por la mayor restricción proporcionada en las condiciones con cambio de dirección y por el hecho de que los movimientos lineales del software sean resultado de acciones angulares de las articulaciones de los miembros superiores.

PALABRAS LLAVE: objetivos espaciales, velocidad de precisión, ley de Fitts.

CONTROLE DE MOVIMENTOS RÁPIDOS E PRECISOS

RESUMO

O presente estudo analisou a hipótese dos componentes independentes velocidade-precisão no controle de movimentos rápidos e precisos. Doze universitários destros com idade média de 23 anos (DP=2,67) participaram do estudo. Atarefa foi mover um cursor de computador controlado por uma caneta e uma mesa digitalizadora em direção a alvos espaciais. Foram manipulados distância entre os alvos, tamanhos dos alvos e a direção a ser percorrida pelo cursor. Foi verificado menor tempo de movimento na condição em que não houve mudança de direção, em comparação as demais condições (P<0,05). Assim, não foram fornecidos indícios à favor da hipótese dos componentes independentes velocidade-precisão. Tais resultados foram explicados pela maior restrição proporcionada nas condições com mudança de direção e pelo fato dos movimentos lineares do software ser resultado de ações angulares das articulações dos membros superiores.

PALAVRAS-CHAVE: alvos espaciais; velocidade-precisão; lei de Fitts.