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ORIGINAL ARTICLE

Effect of reduced visual acuity on precision of two-dimensional tracing movements

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KEYWORDS
Eye–hand coordination;
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Abstract
Purpose: We intended to assess consequences of reduced visual acuity for performance in a natural simple motor task (tracing) using objective kinematic performance measures. Specifically, we intended to elucidate the kind of relationship between the task performance and best corrected binocular visual acuity and to determine the threshold of visual acuity when task performance starts to deteriorate.
Methods: Ninety-five individuals with different best corrected visual acuity participated in the study (age 49 ± 12 years, mean ± SD, 27 men and 68 women). The participants manually traced maze-like visual patterns of different spatial complexity presented on the screen of a portable notebook computer using Clinical Kinematic Assessment Tool software. Tracing error was computed as performance measure in each trial with a spatial pattern matching technique – rigid point set registration method.
Results: The segmented linear regression analysis showed that the relation between visual acuity and tracing errors was best described with a regression function having a break point between two data segments. Tracing performance was unaffected by values of visual acuity below 0.2 on logMAR scale, but when logMAR values increased above this critical limit (i.e. when visual acuity is further reduced), tracing errors linearly increased. The rate of the increase of the tracing error correlated with the complexity of visual stimulus shape.
Conclusion: Testing of fine motor functions with objective kinematic measures during visuomotor tasks may help differentiating between actual effects of reduced visual acuity on eye–hand coordination in individuals with similar levels of impairment of visual acuity.

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PALABRAS CLAVE
Coordinación ojo-mano;
Trazado;
Agudeza visual;
Baja visión

Efecto de la reducción de la agudeza visual sobre la precisión de los movimientos bidimensionales de trazado

Resumen
Objetivo: Tratamos de evaluar las consecuencias de la reducción de la agudeza visual sobre el desempeño de una tarea motora simple y natural (trazado) utilizando mediciones cinemáticas y objetivas del desempeño. De manera específica, tratamos de esclarecer el tipo de relación entre el desempeño de la tarea y la agudeza visual binocular mejor corregida, así como determinar el umbral de la agudeza visual a partir del cual el desempeño de la tarea comienza a deteriorarse.
Métodos: Participaron en el estudio noventa y cinco personas con diferente agudeza visual mejor corregida (edad 49 ± 12 años, media ± DE, 27 hombres y 68 mujeres). Los participantes trazaron manualmente patrones visuales de tipo laberíntico de diferente complejidad espacial, presentados en la pantalla de un ordenador portátil utilizando el software Clinical Kinematic Assessment Tool. El error de trazado se computó como medición del desempeño en cada ensayo, con una técnica de correspondencia del patrón espacial: el método de registro del conjunto de puntos rígidos.
Resultados: El análisis de la regresión lineal segmentada reflejó que la relación entre la agudeza visual y los errores de trazado se describía mejor con una función de regresión con un punto de ruptura entre los dos segmentos de datos. El desempeño del trazado no se vio afectado por valores de agudeza visual inferiores a 0,2 en una escala logMAR (superior a 0,63 en una escala decimal), pero cuando los valores de logMAR superaban este límite crítico (es decir, cuando la agudeza visual empeoraba aún más), los errores de trazado se incrementaban de modo lineal. La tasa de incremento del error de trazado se correlacionó con la complejidad de la forma del estímulo visual.
Conclusión: Las técnicas de medición objetiva del desempeño motor durante las tareas visomotoras en personas con diferente agudeza visual pueden aportar un punto de corte ecológicamente válido y preciso para la definición de la discapacidad debida a la disfunción visual.

Introduction

A substantial number of people (about 4% of the world population[1,2]) suffer from visual impairment conditions. With the increasing number of elderly individuals in the population, the number of people with visual impairment due to age related ophthalmic conditions can be expected to increase even more despite the progress in ophthalmic health care.[3] This is because most aspects of visual function exhibit a linear decline with increasing age.[4] Visual impairments have enormous social and economic implications in terms of economic loss and loss of productivity.[5] Impaired vision has adverse effects on daily functioning.[6] Impaired vision significantly affects performance of fine visuomotor tasks, such as handwriting,[7,8] a task that puts high demands on sensory and motor integration to achieve proper eye–hand coordination.[33,34]

Adverse effects of visual impairment on daily functioning so far typically have been investigated with the use of persons' self-ratings in terms of subjective assessment of daily functioning, self-efficacy, quality of life[6,9,10] or with observer assessed functional tests.[11,12] Although manual motor tasks are used for evaluation or training of eye–hand coordination, for example tracing tasks during rehabilitation of people with low vision to increase writing skills,[13] performance in such tasks is typically assessed using scoring procedures by observers, without application of objective kinematic measurements. Objective quantification of motor task parameters provides a more exact basis for an understanding of functional decrements due to impaired vision. Thus, in laboratory settings, objective kinematic measures have been used to assess performance during grasping in individuals with glaucoma and amblyopia.[14,15] Objective measurement of movement parameters during writing-like visuomotor tasks may be achieved with the help of recently developed software, Clinical Kinematic Assessment Tool (C-KAT).[16] It could be used to quantify the effects of visual impairment on eye–hand coordination using kinematic measures of performance in simple visuomotor tasks executed on the screen of a portable computer.

Thresholds of visual acuity for definitions of visual impairment conditions, such as low vision, have been in use for several decades.[17] The World Health Organization currently defines low vision as best corrected visual acuity <0.33 on the decimal scale (>0.48 logMAR scale).[18] However, the criteria for visual impairment conditions, like low vision, may vary widely, with criteria being defined functionally (disability-based definitions) or being linked to certain thresholds of visual acuity (impairment-based definitions), or combinations of that.[19] Although disability-based definitions are linked to detriments in motor abilities, no objective continuous measure of motor performance is