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Attention impairment in electrooculographic control of computer functions

Joseph J. Tecce[a,*], Linen J. Pok[b], Michael R. Consiglio[c], Jennifer L. O'Neil[d]

[a]*Psychology Department, McGuinn 506, Boston College, Chestnut Hill, MA 02467-3807, USA*
[b]*Ohio State University College of Optometry, 338 W. 10th Avenue, Columbus, OH 43210, United States*
[c]*Biopharmaceutical Contract Manufacturing Services, The Dow Chemical Company, 100 Technology Way, Smithfield, RI 02917, United States*
[d]*Investor Services, State Street Corporation, 150 Newport Avenue, North Quincy, MA 02171, United States*

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Abstract

Previous work has demonstrated that computer functions can be controlled by eye movements recorded with the use of vertical and horizontal electrooculography (EOG). In the present study, an attempt was made to show that this newly developed task could be disrupted by dual-task demands and, therefore, would follow conventional principles of multiple-task performance. Fifteen participants performed the eye movement task under two conditions—control and divided attention. It was found that the time to process letters was significantly longer in the divided attention condition than in the control condition and that males and females showed comparable performance decrements in the divided attention condition. A task that utilizes eye movements to control computer operations for syntax construction follows the same principles of limited resource allocation of attention as more conventional perceptual-motor tasks such as reaction time and manual control of computer functions.

Keywords: Eye movements; Electrooculography; Computer control; Divided attention; Distraction; Multitasking; Developmental disability

Previous work has shown that computer functions can be controlled by eye movements recorded with the use of electrooculography (EOG) (Tecce et al., 1998). The conversion of vertical and horizontal EOG potentials to a cursor on a computer display permits syntax construction in the same way accomplished by a conventional hand-held mouse. However, use of a conventional mouse in cursor control is disrupted by the requirement of a secondary task involving cognitive activity (Shin and Rosenbaum, 2002). This finding raises the possibility that the newly developed EOG method of computer control may also be susceptible to impairment during dual task performance. If so, such a finding would be conceptually significant in showing that the eye movement technique follows the same principles of multiple task performance that characterize traditional perceptual-motor tasks such as reaction time and manual

* Corresponding author. Tel.: +1 617 552 4121; fax: +1 617 552 0523.
E-mail address: tecce@bc.edu (J.J. Tecce).

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control of computer functions (Meyer and Kieras, 1997; Schumacher et al., 1999; Shin and Rosenbaum, 2002). This demonstration would also be of practical importance in showing that performance on the eye movement task is optimal when distraction is minimized. The present study assessed the possibility that divided attention would disrupt ocular control of computer functions. We chose as a secondary task one that has been shown to alter attention and electrical brain activity by cognitive functioning, i.e., mental arithmetic by serial addition (Eason et al., 1964; Tecce and Hamilton, 1973).

Fifteen college undergraduates (nine females) served as nonpaid volunteers. Their age range was 19–23 years (mean=21.11, S.D.=1.11). All had normal (corrected) vision and normal hearing. None reported any major medical or psychiatric problems at the time of testing. Signed informed consent was obtained.

Participants viewed an alphabet matrix displayed on a Macintosh Quadra 950 computer monitor (Fig. 1). The distance between the subject's nasion and the computer screen was approximately 64 cm. The vertical angle of regard to the middle of the display was approximately zero. The alphabet matrix (11.7 cm high and 20.6 cm wide) was presented as a black and white computer display. Letters were 6.0 mm high and ranged from 3.5 to 6.0 mm wide (depending on shape). The visual angle subtended by each letter was 0.54°. Each letter appeared in the middle of a bin that measured 29×29 mm.

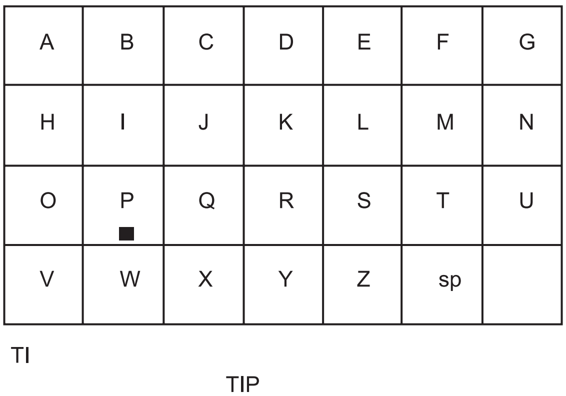

Fig. 1. Computer display of the alphabet matrix used in a matching-to-sample task. In this case, the sample is the word "TIP", which is shown centered and beneath the matrix. With the use of eye movements, participants are able to match each letter in the word by moving the black square cursor so that it rests in the bin containing the intended stimulus letter. Here, the subject has successfully selected each of the first two letters ("T" and "I") and they appear to the left and beneath the matrix. Selection of the final letter ("P") completes the match.

A matching-to-sample task required that letters be selected from the alphabet matrix by using eye movements that positioned a cursor (black square) in one of the bins of the matrix (see Fig. 1). The location of the cursor was determined by ocular potentials recorded from vertical and horizontal EOG leads. As can be seen in Fig. 1, the sample stimulus "TIP" was successfully matched by consecutive selections of the letters "T" and "I". Selection of the final letter "P" completes the match.

There were two types of test conditions. In the control condition, participants used eye movements to perform syntax construction of five three-letter test words ("tip", "bat", "was", "pan" and "war"). The divided attention condition was the same as the control condition except that participants were also required to perform mental arithmetic by adding sevens aloud ad seriatim during syntax construction. The sequence of conditions for testing was: (1) control, (2) divided attention and (3) control.

A Grass Model 78D was used to record bipolar direct-current (DC) potentials from the eyes with the use of standard Beckman 9-mm silver–silver chloride electrodes. For vertical EOG, electrodes were placed 2.0 cm above the right eyebrow and 2.0 cm below the right lower eyelid. For horizontal EOG, electrodes were placed at the outer canthi 2.5 cm from the corner of the juncture of the eyelids. A gold clip electrode on the right ear served as ground. Grass 7P122 amplifiers had a gain of 10,000 and a high frequency cut-off of 75 Hz (50% amplitude reduction) with 12 dB per octave roll-off. Balance voltages from the amplifiers were applied manually as needed to compensate for changes in electrode potentials between trials. The EOG baseline was sufficiently stable to permit adequate control of the cursor. EOG analog outputs from the amplifiers were fed into a Quadra 950 via National Instruments data acquisition boards that performed analog to digital conversion.

Computer software permitted the acquisition of 12-bit samples of the vertical and horizontal EOG signals every 1/60th of a second, applied an exponential smoothing function, and converted the resulting