An eye movement strategy to compensate for age-related cognitive decline in a logistics task*

Bayerischer Forschungsverbund FitForAge

Neuberger, M. B.[1], Knigge, I. C. [1] & Walch, D.[2]

[1] **Institut für Experimentelle Psychologie, Universität Regensburg**
[2] **Lehrstuhl für Fördertechnik, Materialfluss und Logistik, Technische Universität München**
martin.neuberger@psychologie.uni-regensburg.de

Introduction

Aging is not only associated with a decrease of physiological performance measures like maximal heart rate (Tanaka, Monahan & Seals, 2001), but also with a decline of many fluid cognitive functions (Baltes, Staudinger & Lindenberger, 1999). Nevertheless job performance seems to be maintained over the lifespan (Salthouse, 1994). This apparent discrepancy can be explained in terms of the selection of particular goals, the optimization of goal-directed activity, and the compensation of loss by allocating internal and external resources (Baltes & Baltes, 1990). The aim of the present study was to investigate, if covered compensation strategies could be revealed by measuring eye movement activity.

Methods

Design & Procedure

A prototypical work task was taken from the field of physical logistics (*order picking*). Guided by an item list subjects had to search for products on a storage rack, to pick a specified number and to deposit them in a box. Participants were instructed to work as quickly and accurately as possible (figures 1 and 2).

A headmounted eye tracking device (SMI, Teltow) was used for recording eye movements during the task (figure 3). Additionally heart rate was monitored by a pulse watch (Polar).

Figure 1: Participant collecting products.

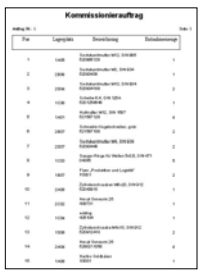

Figure 2: Item list.

To verify age related differences in basic cognitive functions, subjects completed a battery of cognitive tests. The Embedded Figures Test (EFT, Horn, 1983), digit span (Tewes, 1991) and the Trail Making Test (TMT, Reitan, 1958) were used for the assessment.

Participants

20 under the age of 40 years (*M* = 26,5; *SD* = 3,4; 10 female; 10 male)
20 over the age of 40 years (*M* = 53,9 ; *SD* = 7,9; 10 female; 10 male)

Dependent variables

1. Work speed
2. Task errors:
   - wrong product
   - missing product
   - wrong number
3. Average heart rate (HR)
4. Number of fixations per min

Figure 3: Picture from the eye tracking camera, the red cross indicates the actual gaze position.

Results

Cognition and work performance

The group of older participants showed significant lower performance on all cognitive tests, except digit span forward. Groups did not differ in work speed or accuracy (table 1).

Table 1: Performance on cognitive tests and work task

	< 40 years	> 40 years	*U*-Test
EFT hits	34.2 ± 4.9	26.5 ± 6.9**	*p* = .000
EFT time (s)	155.7 ± 32.5	179.9 ± 0.5*	*p* = .012
digit span	16.1 ± 3.8	14.0 ± 3.1*	*p* = .026
digit span forward	8.4 ± 2.1	7.5 ± 2.0	*p* = .051
digit span backward	7.7 ± 2.0	6.6 ± 1.6*	*p* = .024
TMT-A time (s)	25.8 ± 9.5	33.6 ± 8.3*	*p* = .014
TMT-B time (s)	52.1 ± 16.4	76.4 ± 24.8**	*p* = .000
work speed (s)	140.0 ± 42.7	145.6 ± 46.0	*p* = .553
task errors	4.1 ± 3.8	5.0 ± 3.7	*p* = .633
wrong product	0.3 ± 0.6	0.2 ± 0.5	*p* = .675
missing product	0.1 ± 0.3	0.1 ± 0.3	*p* = .965
wrong number	3.8 ± 3.9	4.8 ± 3.9	*p* = .633

* *p* ≤ .05, ** *p* ≤ .001 compared to participants < 40 years (*U*-Test).

Physiological data

Slightly higher average heart rates could be observed in the younger participants (figure 4). However, these differences did not reach significance (*U*-Test: HR1: *p* = .108; HR2: *p* = .074; HR3: *p* = .068).

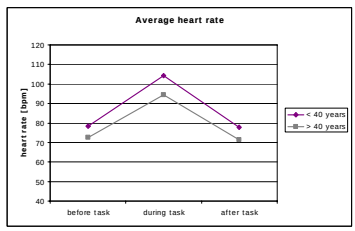

Figure 4: Average heart rate before, during and after order picking.

Eye movements

During the time course of the work task a lower number of fixations per min was measured in the group of subjects over the age of 40 years (figure 5). This effect was significant for the second minute (*U*-Test: 1st min: *p* = .229; 2nd min: *p* = .043; 3rd min: *p* = .400).

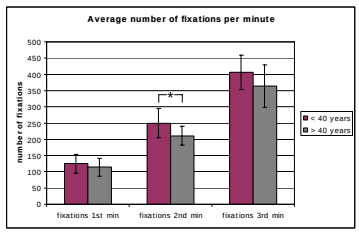

Figure 5: Average number of fixations.

Discussion

In spite of typical findings of lower performance at fluid cognitive capacities and lower heart rate the older partcipants were able to achieve a result on the logistics task just as well as the younger subjects. Eye movement analysis provides a possible explanation for this finding. Participants over the age of 40 years had a lower number of fixations during the most critical phase of the work task. This could be interpreted as a more selective information uptake process. According to SOC-theory (Baltes & Baltes, 1990) older subjects gather less information, but use it in an optimized way. Thus they are able to compensate for reduced fluid cognitve functions. In contrast, younger subjects are capable of gathering more information in the same time, but don't process it as thoroughly as the older participants do. Further research could use the order picking paradigm to assess age related differences concerning the use of energetic capacities in context of vigilance.

Literature:

Baltes, E. B., & Baltes, M. M. (1990). Psychological perspectives on successful aging: The model of selective optimization with compensation. In E B. Baltes & M. M. Baltes (Eds.), *Successful aging: Perspectives from the behavioral sciences* (pp. 1-34). Cambridge, England: Cambridge University Press.
Baltes, P. B., Staudinger, U. M. & Lindenberger, U. (1999). Lifespan psychology: Theory and application to intellectual functioning. *Annual Review of Psychology, 50,* 471-507.
Horn, W. (1983). *Leistungs-Prüf-System* (2. Aufl.). Göttingen: Hogrefe.
Reitan, R. M. (1958). Validity of the Trail Making Test as an indicator of organic brain damage. *Perceptual & Motor Skills, 8,* 271–76.
Salthouse, T. A. (1994). Age-related differences in basic cognitive processes: Implications for work. *Experimental Aging Research, 20,* 249-255.
Tanaka, H., Monahan, K. D. & Seals, D. R. (2001). Age-predicted maximal heart rate revisited. *Journal of the American College of Cardiology, 37,* 153-156.
Tewes, U. (2000). *Hamburg-Wechsler Intelligenztest für Erwachsene*. Bern: Huber.

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