

Performance efficiency and its changes among aging municipal employees

by Sakari Suvanto, MSc, Pekka Huuhtanen, PhD, Clas-Håkan Nygård, PhD, Juhani Ilmarinen, PhD¹

SUVANTO S, HUUHTANEN P, NYGÅRD C-H, ILMARINEN J. Performance efficiency and its changes in aging municipal employees. *Scand J Work Environ Health* 1991;17(suppl 1):118-21. The aims of the study were to compare the performance efficiency of aging municipal workers in different work categories and to determine the changes that occurred in visual search, short-term memory, and fine motor performance over a four-year follow-up period beginning at about 51 years of age. The mental capacity of the workers in mental work was better than that of the workers in physical and mixed physical and mental work, and the results between the physical and mixed work groups did not differ significantly. In four years, the workers' complex short-term memory weakened 6-7 % in all three work content groups. Fine motor speed decreased 2-7 % in the physical and mental work groups. It was concluded that the mental capacity of older workers depends on the mental demands of their work tasks. The weakening of performance is 2-7 % between the ages of 51 to 55 years.

Key terms: aging, fine motor speed, profile groups, short-term memory, work content, visual search.

Age-related physiological changes that occur in perception, information processing, and motor performance may weaken most parts of a person's mental capacity (1). Physiological changes that occur in the sense organs with age weaken the signals from these organs to the brain, and therefore the perception of the senses is weakened.

Physical and mental capacities weaken in different ways. Hearing and the expiratory volume of the lungs decline linearly with age (2). Hand-grip strength weakens linearly after 40 years of age. The weakening of visual acuity with age is also linear, but the correlations with age are low (-0.30 — -0.42) (2).

Aging persons' difficulties to store and retain information are probably due to the weakened ability of long-term memory to store information (1). The weakening ability of older persons to trace information stored in their memory delays and hampers the recognition of things and objects because the process requires the coordination of received information and earlier tracings. On the other hand, the recognition process depends on the memory material at a person's disposal. In other words, the rich experience of older persons helps to compensate for their weakening ability to trace stored information.

In the problem solving measured by Raven's Progressive Matrices, digit coding and perceptual mazes, mental capacity weakens nearly linearly with age. Vocabulary and writing speed, on the other hand, have been shown to be highest among 40- to 50-year-olds and lowest among 20- and 70-year-olds (2).

Motor abilities also change between 20 and 60 years of age. In general, the coordination and control of large movements of the body by the central nervous system, complex choice-reaction times, and decision making become slower (1).

Cognitive performance, according to the vocabulary, arithmetic reasoning, number repetition, and block design subtests of the Wechsler Adult Intelligence Scale, has been shown to depend significantly on age in cohorts of persons born in 1906-1910, 1926-1930, and 1946-1950 (3). It also depended on the socioeconomic status of the subjects and was lower in workers than in lower clerical workers and best in higher clerical workers (3).

Earlier results indicating the weakening of capacity with age are based on cross-sectional study designs. The causes of the poorer results of aged persons may therefore be, for example, the differences in education between different-aged cohorts. The high prevalence rate of diseases among elderly people may also be an explanatory factor in the decrease of their performance. At present information about the relationships between mental capacity, its age-related changes, and specific work content is lacking. Thus the aim of this study was to compare the level of mental capacity among workers in different work categories and to determine the changes in mental capacity among municipal workers over a four-year period, beginning at the age of about 51 years.

Subjects and methods

The subjects were the same as those in a study of musculoskeletal capacity, and they have been described elsewhere (4). The mental capacity of all 137 subjects

¹ Institute of Occupational Health, Helsinki, Finland.

Reprint requests to: Mr S Suvanto, Department of Physiology, Institute of Occupational Health, Laajaniityntie 1, SF-06280 Vantaa, Finland.

in 1985 is presented first. The changes in capacity from 1981 to 1985 are then presented for 83 employees.

The mean age of the women (N = 72) in the cross-sectional study was 54.8 years, and that of the men (N = 65) was 55.3 years. In 1981 the mean age of the men (N = 39) and women (N = 44) who were followed for the next four years was 51.3 and 51.1 years, respectively.

Psychological tests

Subtests of the Wechsler Adult Intelligence Scale were used (5, 6). Verbal concept formation was measured with the similarities subtest, visuoconstructive ability with the block design subtest, visuomotor speed with the digit symbol subtest, and basic perceptual and conceptual abilities with the picture completion subtest. These four tests were carried out only with the subjects (N = 137) in the cross-sectional study in 1985.

Three additional tests were also used in the follow-up study both in 1981 and in 1985. Visual search was measured with a Bourdon-type letter cancellation test. The task was to search through rows of letters on a standard-sized (A-4) sheet of paper and cancel one of the five given target letters within 5 min. The result was the number of letters read during 5 min. Auditory short-term memory was measured with the number repetition subtest of the Wechsler scale. It measures the speed and efficiency of basic cognitive operations (7). Fine motor speed was measured with the finger tapping test. The result was the number of taps in 10 s.

Statistical methods

According to the job analysis, three dominating work content groups (physical, mental, and mixed mental

and physical work) and eight profile groups were formed (8). The significances of the differences between the work content groups and between the profile groups were tested with the one-way analysis of variance (ANOVA) and with Student's t-test (9). In the follow-up study, the significance of the changes were tested with the t-test of paired differences and, for the profile groups, with the Wilcoxon matched-pairs signed-ranks test (9, 10).

Results

Cross-sectional study in 1985

The performance of the workers in the mental work group was better than that of the workers in the physical work group (table 1). The workers doing mental work had better verbal concept formation (similarities), visuoconstructive ability (block design), visual search (letter cancellation), and short-term memory (number repetition backwards/forwards) than those doing mixed physical and mental work. The results of the workers in the physical and mixed work groups did not differ significantly from each other.

Of the profile groups which did physical work, the installation workers had better visuoconstructive abilities, visuomotor speed (digit symbol), basic perceptual abilities (picture completion), and fine motor speed of the left hand (finger tapping right hand/left hand) than the auxiliary workers did (table 2). In the mixed work group, the nurses had better concept formation, visuoconstructive abilities, and visuomotor speed than the transport workers. In the mental work group, the administrative workers had better concept formation than the office workers, but the results did not differ significantly in other respects.

Table 1. Means and standard deviations of the raw scores of the test results of the subjects (N = 137) in the cross-sectional study by work content group (physical work, mixed physical and mental work, and mental work). (ANOVA = analysis of variance, NS = not significant)

Test	Score range	Work content group								
		Physical work (N = 53)			Mixed work (N = 21)			Mental work (N = 63)		
		Mean	SD	t-test	Mean	SD	t-test	Mean	SD	ANOVA
Similarities	0-26	15.3	6.8	NS	17.6	4.0	***	22.5	2.7	***
Digit symbol	0-90	32.7	10.7	NS	34.7	11.0	NS	50.3	10.3	*
Block design	0-48	28.1	9.4	NS	27.2	6.0	***	37.1	7.8	***
Letter cancellation	0-1020	419.8	145.8	NS	409.6	172.0	***	576.6	158.2	***
Errors cancellation	0-66	24.0	21.0	NS	13.5	8.7	*	21.5	21.4	NS
Picture completion	0-21	11.5	3.8	NS	13.0	3.1	NS	14.4	3.3	***
Number repetition										
Backwards	3-9	3.9	0.9	NS	4.0	0.9	**	4.6	0.8	***
Forwards	3-8	5.5	0.8	NS	5.5	0.7	NS	5.8	0.8	*
Finger tapping										
Right hand	31-59	45.2	7.0	NS	47.8	9.2	NS	49.7	7.1	**
Left hand	24-57	40.4	8.4	NS	41.5	8.5	NS	44.6	6.4	*

* P < 0.05, ** P < 0.01, *** P < 0.001.

Table 2. Means and standard deviations of the raw scores of the test results of the subjects (N = 137) in the cross-sectional study by work profile group. (Mixed work = mixed physical and mental work, ANOVA = analysis of variance)

	Physical work									Mixed work						Mental work								
	Auxiliary (N = 33)			Installation (N = 9)			Home care (N = 10)			Transport (N = 12)			Nursing (N = 9)			Office (N = 12)			Administra- tive (N = 25)			Teaching (N = 27)		
	Mean	SD	t- test	Mean	SD	t- test	Mean	SD	ANOVA	Mean	SD	t- test	Mean	SD	Mean	SD	t- test	Mean	SD	Mean	SD	ANOVA		
Similarities	14.2	7.1	NS	16.8	6.4	NS	17.0	6.6	NS	15.6	3.9	**	20.2	2.2	21.6	2.2	*	23.3	1.9	22.0	3.4	*		
Digit symbol	30.6	9.5	**	41.2	9.6	NS	28.9	5.6	**	28.7	9.1	**	42.7	8.0	54.6	10.1	NS	50.4	9.2	48.8	11.2	NS		
Block design	25.6	9.1	**	35.3	7.5	NS	27.6	8.6	**	24.6	5.4	*	30.9	4.9	35.8	8.7	NS	37.0	8.7	38.1	7.0	NS		
Picture completion	10.9	3.7	**	14.9	3.1	NS	10.1	3.4	**	12.5	3.6	NS	13.8	2.4	13.8	2.9	NS	14.4	3.5	14.6	3.2	NS		
Letter cancellation	415.0	153.0	NS	409.7	127.1	NS	419.3	139.8	NS	367.1	12.3	NS	466.3	106.5	619.5	127.8	NS	557.3	116.3	577.3	161.6	NS		
Number forwards	5.4	0.8	NS	6.8	0.8	NS	5.4	0.5	NS	5.4	0.8	NS	5.7	0.7	6.0	1.0	NS	5.8	0.8	5.8	0.8	NS		
Repetition backwards	3.8	0.9	NS	3.8	0.8	NS	3.9	0.7	NS	3.9	0.8	NS	4.0	1.0	4.8	0.9	NS	4.5	0.8	4.7	0.8	NS		
Finger right	44.3	6.5	NS	48.5	7.0	NS	43.5	5.8	NS	47.1	14.5	NS	48.8	5.3	46.3	5.9	NS	51.1	8.5	50.4	6.2	NS		
Tapping left	38.8	8.5	**	47.0	6.3	NS	38.0	4.0	**	41.3	9.6	NS	41.9	7.3	41.7	8.0	NS	45.6	6.8	45.4	5.8	NS		

Table 3. Mean scores (in 1981) and the percentage of change in the scores for visual search in the follow-up study (N = 83) according to the work content group (physical work, mixed physical and mental work, and mental work).

Work content group	Number of workers	Mean score in 1981	Percentage of change in 1985
Physical work	28	456	-4
Mixed work	21	429	-5
Mental work	34	556	+9
All	83	489	+5

Four-year follow-up study

Changes in visual search. In four years the ability for visual search weakened in the physical and mixed work content groups, but became better among workers in the mental work group. The changes were not significant (table 3). Among the profile groups visual search weakened (17 %) nearly significantly for the transport workers.

Changes in short-term memory. Simple auditory short-term memory improved 10 % in the physical work content group and weakened 6 % among workers doing mental work during the four years ($P < 0.05$). Complex auditory short-term memory weakened in all the groups by 6–7 %, but the weakening was not significant (table 4). The weakening was 18 % for the profile group of nurses and 10 % for that of administrative workers ($P < 0.05$).

Changes in fine motor performance. The fine motor speed of the right hand weakened 2–3 % in the physical and mental work groups (table 5). As regards the left hand, the weakening was 2–7 % in all three work

content groups. The changes were not significant for either the work content groups or the profile groups.

Discussion

The level of mental capacity was related to the work requirements of the municipal workers. It was highest in tasks with high demands for information processing and decision making (mental work) and lowest in tasks with dynamic or static muscular work (physical work). Among older persons mental capacity seems to depend on the cognitive demands of the work tasks. The results suggest that the possibilities provided by work tasks to develop one's abilities explain the observed differences. The selection on the basis of education may also partly explain the differences in mental capacity. The results support the earlier observation that the performance efficiency of older and retired workers depends on their socioeconomic status (3).

The changes in performance were clearest for fine motor speed and complex short-term memory. This result was probably due to the slower central information processing of older persons (1, 11). However, the number of subjects in the different work content and profile groups was small, and the follow-up period was short. These two factors may be partly responsible for the fact that the weakening of performance was not systematic or marked.

The weakening of performance was not especially strong in any of the profile groups, except for the weakening of visual search among the transport workers and that of short-term memory among the nursing and administrative workers (tables 3 and 4). Transport work involves a continuous search of visual information from the work environment and the transformation of this information to motor reactions. In nursing and administrative work the memory load of different tasks is high. It is therefore tempting to hypothesize

Table 4. Mean scores (in 1981) and the percentage of change in short-term memory in the follow-up study (N = 83) according to the work content group (physical work, mixed physical and mental work and mental work).

Work content group	Number of workers	Short-term memory		Complex short-term memory	
		Mean score in 1981	Percentage of change in 1985	Mean score in 1981	Percentage of change in 1985
Physical work	28	5.1	+ 10*	4.1	- 7
Mixed work	21	5.6	- 1	4.3	- 6
Mental work	34	6.3	- 6*	5.1	- 6
All	83	5.7	+ 1	4.5	- 6

* P < 0.05.

Table 5. Mean scores (in 1981) and the percentage of change in fine motor speed in the follow-up study (N = 83) according to the work content group (physical work, mixed physical and mental work, and mental work).

Work content group	Number of workers	Right hand		Left hand	
		Mean score in 1981	Percentage of change in 1985	Mean score in 1981	Percentage of change in 1985
Physical work	28	47	- 2	43	- 7
Mixed work	21	48	+ 2	43	- 2
Mental work	34	50	- 3	45	- 3
All	83	48	- 1	44	- 3

that the weakening of mental capacity in these three profile groups was due to the one-sided and high demand level on the central nervous processes responsible for visual search and short-term memory. The observed weakening can be considered analogous to the weakening of muscular strength and cardiorespiratory capacity due to static physical work among older persons (4, 12). However, the finding that, in office work, which demands rapid visual search, the level of visual search was the best of all the profile groups and it did not weaken during the four-year follow-up period seems to contradict this hypothesis. In addition, in the installation profile group, whose work demands fine motor abilities, the level of fine motor speed of the nondominant hand was highest of all the profile groups, and the speed of neither hand weakened during the follow-up period. Nevertheless, the demands on fine motor performance in the installation profile group and the demands for rapid visual search in office work can be less one-sided and less loading than the short-term memory and visual search of nurses and transport workers. Thus the hypothesis should be studied in conjunction with an intensive work analysis.

The long-term effects of specific mental job demands on the corresponding efficiency of perceptual, information-processing, and motor processes should also be studied in subsequent research.

It can be concluded that the level of mental capacity depends on the mental demands of work tasks and is highest among workers doing mental work and lowest among those doing physical work. In addition short-term memory and fine motor speed weakens 2—7 % between the ages of 51 and 55 years.

References

1. Welford AT. Perception, memory, and motor performance in relation to age. In: Birren JE, Munnichs JMA, Thomae H, Minors M, ed. *Aging: a challenge to science and society*. Oxford: Oxford University Press, 1983: 297—311.
2. Chown SM. Profiles of abilities. In: Birren JE, Munnichs JMA, Thomae H, Minors M, ed. *Aging: a challenge to science and society*. Oxford: Oxford University Press, 1983:264—75.
3. Heikkinen E, Arajärvi R-L, Era P, et al. Functional capacity of men born in 1906—1910, 1926—30 and 1946—50: a basic report. *Scand J Soc Med Suppl* 1984;33: 1—93.
4. Nygård C-H, Luopajarvi T, Ilmarinen J. Musculoskeletal capacity and its changes among aging municipal employees in different work categories. *Scand J Work Environ Health* 1991;17(suppl 1):110—7.
5. Matarazzo JD. Wechsler's measurement and appraisal of adult intelligence. 5th ed. Baltimore, MD: The Williams and Wilkins Co, 1976.
6. Lezak MD. *Neuropsychological assessment*. 2nd ed. New York, NY: Oxford University Press, 1983:768.
7. Estes WK. Learning, memory and intelligence. In: Sternberg RJ, ed. *Handbook of human intelligence*. New York, NY: Cambridge University Press, 1982:170—224.
8. Ilmarinen J, Suurnäkki T, Nygård C-H, Landau K. Classification of municipal occupations. *Scand J Work Environ Health* 1991;17(suppl 1):12—29.
9. DeGroot MH. *Probability and statistics*. 2nd ed. Reading, MA: Addison-Wesley Publishing Company, 1986:723.
10. Siegel S. *Nonparametric statistics for the behavioral sciences*. Tokyo: McGraw-Hill Kogakusha Ltd, 1956: 312.
11. Spirduso WW. Physical fitness, aging, and psychomotor speed: a review. *J Gerontol* 1980;35:850—65.
12. Ilmarinen J, Louhevaara V, Korhonen O, Nygård C-H, Hakola T, Suvanto S. Changes in maximal cardiorespiratory capacity among aging municipal employees. *Scand J Work Environ Health* 1991;17(suppl 1):99—109.