Age differences in perceived workload across a short vigil

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Abstract

The main objective of this research was to investigate age differences in the perceived workload associated with the performance of a demanding, high event rate, vigilance task. Younger workers (n = 26) aged 16 to 35 years (M = 27.8) and older workers (n = 24) aged 45 to 65 years (M = 52.2) completed perceived workload scales (NASA-TLX) following a brief practice session (pretest) on the vigilance task, and then again following a test session (posttest) lasting nine minutes. In relation to the vigilance task, a statistically significant performance decrement was identified, but there was no evidence that performance differed according to age in respect to that decrement. However, a dissociation was found in relation to the perceived workload ratings: While no age differences were found in vigilance performance, the workload ratings revealed older workers to perceive a significantly greater increase in workload from pretest to posttest. Theoretically these findings are considered in relation to the demands placed upon attentional resources, and their implications for both laboratory-based vigilance research, and workplace systems monitoring situations, are discussed.

Introduction

A feature of present day work environments is that workers increasingly are interacting with some form of technology, and frequently are required to monitor automated and semi-automated systems over extended vigils. This trend can be seen in the transport, power, and manufacturing industries, as well as in the healthcare sector. However, automating systems does not necessarily make the operator's task easier (Edwards, 1976), and there is accumulating evidence that the workload demands associated with maintaining a vigil, are relatively high (Warm, Dember, & Hancock, 1996). As such systems are frequently used in safety-critical situations, it is essential to learn more of the factors associated with performance.

This study investigates two factors that may influence performance on a vigilance task; the age of the worker, and the level of workload the operator perceives during a vigil. Research examining age differences in vigilance performance has produced equivocal results in that some studies have found evidence of age variation in performance, while others have not. Further, very few have assessed sustained attention in a population of working ages. Therefore, this study asks, do younger and older workers perceive different levels of workload during the course of a vigil, and how do those perceptions relate to actual performance on a vigilance task?

Attentional resources, vigilance and age

One of the most influential theoretical perspectives on vigilance proposes that performance varies as a function of demands on attentional resources (Davies & Parasuraman, 1982). The greater the demands placed upon the operator by the vigilance task, the greater the drain on attentional resources due to fatigue, and the more vigilance performance suffers. Empirical support for this perspective is provided by several experimental paradigms including dual-task performance (e.g. Parasuraman, 1985), and subjective ratings of perceived workload (see Warm et al., 1996). With regard to the latter approach, as task demands increase, declines in perceptual sensitivity across the task are accompanied by increases in perceived workload ratings (Dember, Warm, Nelson, Simon, Hancock & Gluckman, 1993). Moreover, work employing subjective measures generally show mental and temporal demands, and frustration to be the primary source of reported workload (e.g. Temple, Warm, Dember, Jones, LaGrange, & Matthews, 2000; Warm et al., 1996).

Vigilance can be measured in terms of aggregate performance (mean performance across the task), or in respect to a vigilance decrement (performance at the end of the vigil relative to the beginning). With regard to the former, a review of 11 studies of vigilance (Davies & Parasuraman, 1982) found the detection rate to be lower among older adults in six of those studies, while four found the false alarm rate to be higher among older adults. Since then several studies have found evidence of age differences (e.g., Bunce, Barrowclough & Morris, 1996; Giambra, 1997; Parasuraman, Nestor, & Greenwood, 1989; Parasuraman & Giambra, 1991), although others (e.g. Giambra & Quilter, 1988) have not. Research examining age differences in the vigilance decrement is also inconsistent. For instance, Davies and Parasuraman's (1982) review found six of 11 studies to report a vigilance decrement, of which only four showed older adults to significantly underperform younger adults. Others (e.g. Bunce, in press; Deaton & Parasuraman, 1993; Parasuraman & Giambra, 1991) also reported lower performance among older adults over time. However, several studies have found no evidence of this type (Bunce et al., 1996; Giambra, 1997; Giambra & Quilter, 1988). Giambra (1993) reports that factors other than the "core process of sustained attention" are responsible for age differences in vigilance, such as stimulus exposure time, and degree of signal-nonsignal discrimination. Also, age differences are greater when the level of stimulus degradation is higher (Bunce, in press; Parasuraman et al., 1989). This brief review suggests that factors other than the ability to maintain a vigil per se, are influential in older adults' vigilance performance. Also, most of the work dealing with populations of working ages show minimal age variation in performance. However, given that there are theoretical reasons to expect age differences in the ability to maintain a vigil (see below), even in adults of working ages, is it the case that older individuals are compensating their performance by expending greater resources during vigils?

<u>Perceived workload, age and vigilance</u>

Our review of the literature revealed only one study (Deaton & Parasuraman, 1993) that examined perceived workload within the context of age differences in vigilance. Here performance of younger adults was compared to that of retired adults on a vigil lasting 32.4 minutes. Perceived workload measures and performance were found to dissociate; although no significant Age x Time interaction was found in relation to a vigilance task, that interaction was significant for measures of the perceived mental demands of that task. This would suggest the possibility that age equivalence in sustained attention may be underpinned by increased effort among older adults.

The attentional resource account of vigilance overlaps with those perspectives of cognitive ageing which hold that age-related declines in cognitive performance are due to a decline in processing resources with advancing age (see Salthouse, 1991). In other words, if age differences exist in respect to vigilance, they may be underpinned by age-related variance in processing resources. The present study explores this possibility by examining vigilance performance over time within a population of older and younger workers while recording perceived workload ratings. In contrast to Deaton and Parasuraman’s (1993) earlier study, a short nine-minute, but highly demanding, vigilance task will be used. Given the safety-critical aspects of monitoring work frequently found in the workplace, it is also important to evaluate age differences in performance over short, but demanding, periods of time.

On the basis of attentional resource theory, and resource theories of cognitive ageing, it is predicted that across the course of the vigil (a) older workers will underperform younger workers, and (b) older workers will perceive a greater increase in workload.

Method

Participants

Fifty workers in a UK-based charity organisation helping developing countries were invited to take part in the research. Twenty-six younger workers aged 16 to 35 years (14 women), and 24 older workers aged 45 to 65 years (11 women) formed the two age groups. Mean ages for younger and older groups were 27.81 and 52.17 years respectively. Participants were recruited through e-mail messages sent within the organisation publicising the research. Respondents worked in a wide range of functions including management, administration, teaching and voluntary work. Information was collected relating to the participants’ highest educational qualification, and the National Adult Reading Test (NART: Nelson, 1991) was administered for matching purposes. Any participants reporting the use of medications that could result in drowsiness and lowered alertness were excluded from the study.

Vigilance task

The task was based upon that of Nuechterlein, Parasuraman, and Jiang (1983). A series of monochrome digits (8 mm x 24 mm) were present centrally on the screen of a PC. Digits, which ranged from 0 to 9, were degraded by reversing 30% of the pixels defining the digit and its surround. Participants were required to respond to the target digit 0 by pressing the space bar of the keyboard once. Distracters required no response. Sixty practice trials were administered, and after a break, a total of 540 test trials followed. Both practice and test trials were presented at an event rate of one per second, and signal probability of 0.25. Instructions emphasised speed and accuracy of responding.

For data analysis purposes, test trials were divided into three blocks of 180 trials, with the following measures calculated for each block: mean RT of correct responses (referred to as RT hits), proportion of hits (referred to as hits), and proportion of false alarms (referred to as FAs). Following signal detection theory (Green & Swets, 1998), measures of perceptual sensitivity and criterion also were calculated. As the assumption of a normal distribution of target and nontarget events cannot be made in respect to such vigilance tasks, nonparametric measures of sensitivity, A', and criterion, B, were calculated (Craig, 1978, 1979).

<u>Card sorting task</u>

Following research elsewhere (Dember et al., 1993), for comparative purposes, participants were asked to sort a pack of 52 shuffled playing cards into their respective suits.

<u>Perceived workload</u>

Perceived workload was recorded through the NASA Task Load Index (TLX; Hart & Staveland, 1988). This is a multi-dimensional measure, considered to be one of the most effective available (Hill, Iavecchia, Byers, Zallad, & Christ, 1992; Nygren, 1991). An overall weighted index for the tasks was calculated on the basis of the following six subscales.

<u>Mental Demands</u>. ‘How much mental and perceptual activity was required (e.g. thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving?’ (scale end points, low-high).

<u>Physical Demands</u>. ‘How much physical activity was required (e.g. pushing, pulling, turning, controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?’ (scale end points, low-high).

<u>Temporal Demands</u>. ‘How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?’ (scale end points, low-high).

<u>Own Performance</u>. ‘How successful do you think you were in accomplishing the goals of the task set by the experimenter? How satisfied were you with your performance in accomplishing these goals?’ (end scale points, poor-good).

<u>Effort</u>. ‘How hard did you have to work (mentally and physically) to accomplish your level of performance?’ (scale end points, low-high).

Frustration Level. ‘How insecure, discouraged, irritated, stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?’ (scale end points, low-high).

Each dimension was rated from 0 (low/poor) to 100 (high/good). An overall weighted index was obtained through the procedure devised by Hart and Staveland (1988). Each of the six dimensions was rated against each of the other five dimensions in terms of its importance in performing the task. If perceived as more important by the individual, that dimension was scored 1. These weights were then summed (possible range 0 to 5), and, in order to obtain a weighted rating for each dimension, were multiplied by the dimension rating (0 to 100). The overall workload index was obtained through summing the weighted ratings for each of the six dimensions, and dividing it by 15 (the total number of comparisons that are made overall).

Procedure

Participants attended by appointment a field laboratory set up in a quiet room within the host organisation. Biographical data were collected and then the NART administered. The card sorting task followed, and then finally, the vigilance task. TLX ratings were recorded immediately following the card sorting task, and immediately following both the practice (pretest) and test trials (posttest) of the vigilance task. The entire session lasted about 40 minutes.

Results

Descriptive data for the respective age groups are presented in Table 1. Independent sample t-tests showed age to differ significantly ($t [48] = 16.14$, $p<.001$) between the groups. No differences were found in qualifications, and estimated full scale IQ, indicating the respective age groups to be well matched on those variables. The principle experimental predictions were tested through one-tailed tests, followed by two-tailed post-hoc simple tests where appropriate. As no gender differences were found in respect to either the educational variables, or vigilance task variables, data and statistics are presented for men and women combined.

Vigilance

Data relating to the vigilance task are also detailed in Table 1. A series of 2 x 3 univariate ANOVAs were run on vigilance task variables; age group formed the between-subjects factor, and block the within-subjects factor. None of the statistics obtained in respect to FAs were significant. Regarding the remaining variables however, as the following statistics demonstrate, the main effects for block were significant: RT Hits, F [2,96] = 12.61, η^2 = .208, p = .000; Hits, F [2,96] = 4.05, η^2 = .078, p = .001; A', F [2,96] = 3.82, η^2 = .074, p = .013; B, F [2,96] = 2.69, η^2 = .053, p = .037. In all cases, the data suggest a vigilance decrement from Block A to C. Taking A' for example, means were obtained from Block A to C, respectively, of .955, .950, and .928, indicating a decline in perceptual sensitivity as the vigil progressed.

It is of note though, that in relation to Hits, RT Hits, A', and B, the age main effects, and the Age x Block interactions were all nonsignificant. The null findings in respect to the Age x Block interactions are particularly important, as this is contrary to predictions, and suggests that the vigilance decrement does not vary as a function of age in this working population.

Table 1 about here

Perceived workload

Inspection of the workload ratings reveals a highly interesting dissociation with the vigilance data. Specifically, although older workers achieved performance on the vigilance task comparable to younger workers, their perceived workload increased more markedly across the vigil. This trend is evident in the overall weighted index, and absolute ratings of mental demands, physical demands, temporal demands, and frustration. (Where statistics derived from analyses of the weighted rating scales departed from those obtained from the absolute ratings, it is detailed in the text below.) Pretest and posttest ratings for the subscales and weighted index of the TLX workload scale were subjected to a series of 2 x 2 univariate ANOVAs, with age group as the between-subjects factor, and test-time the within-subjects factor. Means and standard deviations for those data are presented to the left in Table 2, while relevant statistics are presented to the right. Results relating to the overall weighted index, and individual subscales are considered in the following sections.

Overall weighted index. Table 2 indicates that although the age main effect was nonsignificant for the weighted index, the main effect for test-time, and the Age x Test-Time interaction were both significant. Consideration of the means suggests perceived workload to increase from pre- to posttest. The Age x Test-Time interaction was dismantled using post-hoc simple tests to examine pre- and posttest scores within each age group. The simple test for younger workers attained significance at conventional levels ($F [1,49] = 4.12$, $\eta^2 = .078$, $p = .048$). That contrast for older workers was highly significant ($F [1,49] = 23.09$, $\eta^2 = .320$, $p = .000$). Those results suggest that although overall perceived workload increased from pre- to posttest in both age groups, the magnitude of that increase was far greater in older workers. Comparison of effect sizes (η^2) for younger and older workers provides clear support for this conclusion.

Mental demands. Here the age main effect was nonsignificant, whilst that for test-time did attain statistical significance. Consistent with the results obtained for the overall weighted index, mental demands were found to increase from pre- to posttest. As the Age x Test-Time interaction probability level was very close to conventional levels of statistical significance ($p = .058$), post-hoc simple tests were conducted within each age group. The contrast for younger workers was nonsignificant. However, for older workers the simple test was highly significant ($F [1,49] = 17.74$, $\eta^2 = .266$, $p = .000$), strongly suggesting the degree to which perceived mental demands increased across the task was substantially greater among older workers.

Physical demands. Evidence suggesting an age-related differential in physical demands was also obtained. Table 2 shows the age main effect to be nonsignificant, and that for test-time to be highly significant; physical demands were perceived to increase from pre- to posttest. However, the significant Age x Test-Time interaction suggests the magnitude of that increase differed according to age. Post-hoc simple tests within each age group revealed a significant increase in both groups; younger, $F [1,49] = 5.13$, $\eta^2 = .095$, $p = .028$; older, $F [1,49] = 31.41$, $\eta^2 = .391$, $p = .000$. Comparison of effect sizes (η^2) though, clearly indicates the older group perceived a greater increase in physical demands across the task. It should be noted however, that when physical demand ratings weighted by their relative importance were subjected to analysis, that Age x Test-Time interaction was found to be nonsignificant.

Temporal demands. The main effect for age was significant, mean scores (57.4 and 47.6 for younger and older workers respectively) indicating younger workers to perceive greater temporal demands overall. More important though, are the significant main effect for test-time (suggesting increased temporal demands across the task), and Age x Test-Time interaction. With respect to the latter, a post-hoc simple test revealed no significant increase in this type of demand among younger workers. Among older workers however, the simple test did attain significance ($F [1,49] = 9.74$, $\eta^2 = .166$, $p =.003$), demonstrating this age group to perceive a greater increase in temporal demands across the task. When ratings weighted for their importance were subjected to statistical analysis though, the main effects for age and test-time became nonsignificant.

Performance. In respect to the absolute ratings, none of the statistics achieved significance. However, when the weighted version of this scale was analysed, the main effect for test-time was found to be statistically significant, $F [1,48] = 4.86$, $\eta^2 = .092$, $p = .016$. Workers perceived their performance to decrease from practice to the test proper.

Effort. In relation to this variable, Table 2 shows the age main effect did not achieve statistical significance, although that for test-time did; both age groups perceived an increase in effort from pre- to posttest. Although the data suggest an age differential in perceived effort across the task, as the Age x Test-Time interaction did not approach statistical significance at conventional levels ($p = .086$), no further analyses were undertaken for this variable.

Frustration. The significant main effect for age in Table 2 indicates younger workers perceived greater frustration during the vigilance task, the significant main effect for test-time indicating frustration to increase in both groups from pre- to posttest. As the Age x Test-Time interaction was close to conventional levels of statistical significance ($p = .058$), this interaction was also subjected to post-hoc dismantling. The simple test for younger workers proved to be nonsignificant. That for older workers however, was highly significant ($F [1,49] = 12.27$, $\eta^2 = .200$, $p = .001$), indicating that the magnitude of the perceived increase in frustration across the task to be far greater among older workers. However, when the version of this scale weighted for importance was subjected to analysis, the test-time, and Age x Test-Time interaction both were found to be nonsignificant.

Table 2 about here

Card sorting task

Perceived workload ratings were recorded for the card sorting task for comparative purposes. Means for the weighted index are presented in Table 2. As can be seen, card sorting means for both age groups were substantially below pre- and posttest ratings for the vigilance task, a pattern that was also evident on comparing subscale means. Comparisons between TLX scores for both practice and test vigilance tasks, and card sorting, were all significant to at least $p<.02$. Thus, the vigilance task was clearly perceived as being more demanding than the card sorting task across the range of TLX dimensions.

It is also important to identify any differences that may exist in perceived workload between the two age groups of workers on this measure. Comparisons were all nonsignificant with the exception of mental demands ($p<.05$), where older workers found the card sorting task less mentally demanding. In respect to the vast majority of ratings for card sorting however, there were no age-related differences in perceived workload.

Discussion

This study has produced two important findings. First, age differences do not exist in the ability to maintain a vigil in the present population of working ages. Second, age differences do exist in respect to the perceived workload reported across that vigil. The implication is that whilst sustaining a level of attention across the task comparable to younger workers, older colleagues are perceiving a greater increase in demands as the vigil progresses. Specifically, age-related differences were found in relation to increases in mental, temporal, physical demands, and also frustration levels. Thus, a dissociation exists between younger and older workers' vigilance performance, and their increases in perceived workload across the task.

The profile of perceived workload subscale ratings for the present vigilance task were similar to those reported elsewhere (e.g. Temple et al., 2000; Warm et al., 1996). That is, mental and temporal demands were major sources of workload, and were found to differentiate older and younger workers from pre- to posttest. The significant statistics in respect to physical demands were unexpected, but when the relative importance of this source of workload in performing the task was taken into account, those statistics became nonsignificant. It is of interest that younger workers were significantly more frustrated (although age differentials from pre- to posttest in absolute ratings became nonsignificant when the weighted version of the scale was analysed). However, it should be noted that this was not associated with inferior performance in respect to the vigilance task.

These findings are consistent with those of Deaton and Parasuraman (1993), and extend them in two ways. First, in contrast to the 32.4 minute vigil examined by those investigators, here an age-related vigilance-perceived workload dissociation has been found in respect to a short nine-minute vigilance task. Second, our findings have been obtained from a population of working ages (Deaton and Parasuraman's older adults were of post-retirement ages), suggesting that older workers also perceive greater demands in sustaining attention. Theoretically, assuming that the perceived workload ratings tap demands upon attentional resources, this suggests that older workers draw to a greater extent on those resources in order to maintain a vigil relative to their younger colleagues. The practical implications of this conclusion will be addressed shortly.

There are two concerns that need to be taken into account when considering the present findings. First, with the exception of physical demands, the primary source of the significant Age x Test-Time interactions on the TLX workload subscales was older workers reporting lower perceived demands at pretest on the vigilance task. This raises the possibility that older workers initially were systematically using a lower subjective scoring range on the TLX. This seems unlikely as in addition to physical demands, pretest ratings of own performance differed minimally between workers of different ages. Moreover, comparisons of ages differences in the perceived demands associated with card sorting, with one exception (mental demands) revealed all age contrasts were nonsignificant. Therefore, the weight of the evidence suggests older workers to be subjectively using the TLX similarly to younger workers. However, what is clear is that older workers perceived lower demands following a short period of practice on the vigilance task (1 minute), but perceived comparable demands to younger workers following the vigil. The key point is that the magnitude of the perceived workload increase from pre- to posttest is far greater in the older workers. This would suggest that, relative to younger workers, the drain upon attentional resources is far more rapid in the older group. It is possible to speculate, that had the vigil been either longer, or more demanding, the workload posttest scores of the older workers would have exceeded those of their younger colleagues by some way.

The second concern is that no practice data were recorded for the vigilance task. In consequence, it is not possible to consider the TLX ratings relative to vigilance performance measures during the practice session. Therefore, linking practice and posttest TLX ratings to measures of performance across the vigil (i.e. Block A to Block C), but not practice data, may result in a spurious dissociation - the two sets of ratings do not equate temporally to data from the vigilance task. We believe the possibility of a spurious dissociation unlikely, as work elsewhere suggests that perceived demands increase as the vigil progresses. For example, Dember et al., (1993) in a low signal salience task (as in the present experiment) demonstrated the perceived workload ratings of independent groups following vigils of one, two, three, four, five and ten minutes to increase as a function of the length of the vigil. This would suggest that the likelihood of a spurious dissociation underpinning the present findings is low.

These results (and those of Deaton & Parasuraman, 1993) indicate that older workers are equalling their younger colleagues' performance across a vigil, but in doing so are making greater demands on attentional resources during the course of that vigil. Assuming that attentional resources are not unlimited, it would imply that, relative to their younger colleagues, older workers' vigilance performance will suffer sooner. Because this has clear implications for monitoring performance at work generally, and in safety-critical situations in particular, it is important that designers explore means by which age differences (where they exist) can be moderated. One means by which this may be achieved is through providing environmental support. This is "when the external context induces or supports the mental operations appropriate for successful completion of the task" (Craik & Jacoby, 1996, p. 115). An example involving episodic memory is that age differences are generally greater in conditions of free recall, than in those where recognition is required. Therefore, where age differences exist, either in respect to vigilance performance per se, or the perceived workload associated with that performance, it is important to investigate the extent to which environmental support attenuates those age differences. Research already suggests this approach may have some promise. For instance, Manly, Robertson, Galloway and Hawkins (1999) found higher scores on the Cognitive Failures Questionnaire (Broadbent, Cooper, FitzGerald, & Parkes, 1982) to be associated with lower performance on a sustained attention task. However, when they raised the level of environmental support (by increasing the signal probability from .11 to .5 thereby reducing the average time to elapse between signal events), those between-group differences became nonsignificant. These findings were interpreted such that higher environmental support reduced the demands placed upon an endogenous executive system responsible for governing sustained attention (see Stuss and colleagues, 1995, for more on this perspective). Given that Deaton and Parasuraman (1993) found a higher proportion of false alarms among older adults in low event rate task conditions (where the time elapsing between critical signals is also longer), it would suggest that experimental research exploring the level of environmental support in relation to age variation in vigilance performance would be worthwhile.

Turning to the practical implications for workplace monitoring situations, there is considerable evidence that performance is better in manual modes of operation compared to automated versions of the same task, when the operator has to passively monitor the system (Parasuraman, Mouloua, Molloy, & Hilburn, 1996). As the environmental support for mental operations is likely to be inherently greater in the manual modes of operation, from the current perspective, assuming optimal levels of workload are not infringed, we would predict that age variation in monitoring performance and associated mental workload, would be less than in conditions of passive monitoring. This would be an interesting hypothesis to test empirically as it has important implications for systems design. That is, it would suggest the introduction of intelligent interfaces (e.g. Kantowitz, 1989), where the balance between complete operator control, and complete machine control, is viewed as a continuum, would be a worthwhile development. Specifically, as the overall workload of a work task increases (for example, as a pilot moves from the cruise to the descent phase of a flight), automated systems activate to moderate that workload. If it is assumed that the optimal level of environmental support to facilitate task-related mental operations is maintained around the midpoint of that active-passive continuum, performance would benefit, particularly among older operators.

To conclude, the present findings demonstrate that while older workers are able to maintain a short but demanding vigil to the same performance level as their younger colleagues, they are perceiving a greater increase in the workload associated with that vigil. By compensating their performance in this way, it is likely that older adults are placing greater demands on attentional resources. Therefore, the provision of environmental support to facilitate task-related mental operations, is likely to be of particular benefit to older workers. Both laboratory, and applied field tests of this possibility in respect to vigilance and systems monitoring is an important direction for future research to take.

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Table 1. Means (SD) for Biographical Variables and Vigilance Task Variables

Variable			Young		Old		ANOVAs Effect	F Ratio	η^2 =	Sig =
Age			27.81	(4.95)	52.17	(5.72)	N/A			
Highest Qualification			3.19	(1.06)	2.92	(1.14)	N/A			
Estimated Full Scale IQ			121.19	(3.46)	123.08	(3.48)	N/A			
Vigilance Task										
RT Hits (ms)	Block	A	506	(49)	525	(77)	Time	12.61	.208	.000
		B	527	(48)	531	(76)				
		C	539	(62)	541	(78)				
Hits	Block	A	.955	(.057)	.955	(.053)	Time	4.05	.078	.011
		B	.956	(.028)	.944	(.084)				
		C	.933	(.068)	.922	(.125)				
FAs	Block	A	.016	(.016)	.022	(.017)				
		B	.016	(.012)	.019	(.022)				
		C	.016	(.015)	.021	(.013)				
A'	Block	A	.984	(.014)	.983	(.014)	Time	3.82	.074	.013
		B	.985	(.007)	.981	(.022)				
		C	.979	(.018)	.974	(.035)				
B	Block	A	1.003	(.080)	1.021	(.079)	Time	2.69	.053	.037
		B	1.003	(.051)	1.000	(.113)				
		C	.981	(.079)	.984	(.123)				

Note. Degrees of freedom for Time = 2, 96
N/A = not applicable

Table 2. Means (SD) for TLX Perceived Workload Ratings of Vigilance and Card Sorting Tasks

Variable		Young	Old	Effect	F Ratio	η^2 =	Sig.=
				ANOVAs			
Vigilance Task							
Weighted Index	Pretest	55.1 (12.5)	46.2 (16.9)	A			ns
	Posttest	63.5 (12.0)	64.1 (12.4)	TT	28.79	.375	.000
				A x TT	3.61	.071	.031
Mental Demands	Pretest	54.1 (26.0)	43.7 (23.5)	A			ns
	Posttest	65.0 (22.9)	65.6 (20.3)	TT	22.30	.317	.000
				A x TT	2.56	.051	.058
Physical Demands	Pretest	21.6 (17.5)	21.4 (23.4)	A			ns
	Posttest	36.6 (26.3)	53.0 (27.2)	TT	41.12	.461	.000
				A x TT	5.26	.099	.013
Temporal Demands	Pretest	55.7 (25.1)	39.3 (24.6)	A	2.97	.058	.046
	Posttest	59.0 (22.6)	55.9 (23.2)	TT	7.21	.131	.005
				A x TT	3.20	.063	.04
Performance	Pretest	58.0 (20.6)	61.5 (23.1)	A			ns
	Posttest	57.2 (14.7)	59.9 (15.2)	TT			ns
				A x TT			ns
Effort	Pretest	51.2 (20.3)	41.0 (23.7)	A			ns
	Posttest	66.1 (20.1)	65.2 (16.0)	TT	35.12	.423	.000
				A x TT			ns
Frustration	Pretest	38.4 (22.0)	18.6 (15.2)	A	7.32	.132	.001
	Posttest	45.1 (23.1)	36.8 (27.1)	TT	12.23	.203	.001
				A x TT	2.56	.051	.058
Card Sorting Task							
Weighted Index		38.8 (14.0)	37.1 (13.3)	N/A			

Notes
Degrees of freedom = 1,48
A = Age
TT = Test-time N/A = Not applicable