POSTURE EFFECTS ON MENTAL PERFORMANCE AND COGNITIVE MODELING: Literature Review And Preliminary Report

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ABSTRACT

Presented is a brief literature review of posture-induced arousal studies and cognitive modeling procedures as well as a preliminary report on two experiments examining age, sex, and posture effects on reaction time and cognitive modeling. This research is fundamental to understanding the influence of work posture on mental performance particularly in situations where operators may be underaroused or overstimulated.

INTRODUCTION

Working posture does influence mental performance. Human operators of the teleprospector or other teleoperations may benefit from workstation designs which permit a variety of posture including appropriations of field (remote) environments to better stimulate metabolic activity and enhance telepresence. Do operators perform better when standing than when sitting? Does age, sex, and experience make a difference? This paper attempts to provide a better understanding by providing four pieces of information: (1) a brief literature review of posture studies, (2) a short literature review of cognitive modeling, (3) a preliminary report on age differences in posture effects, and (4) a report of sex differences in cognitive modeling. The purpose of this research is to determine the effects of posture and age on mental performance (as measured by reaction time) and integrate findings into a model of information processing.

REVIEW OF LITERATURE

Posture and Reaction Time

Previous experiments examining posture effects indicate that posture affects speed of response in the elderly. Of particular interest is a dissertation by Woods (1981) which examined the effects of different levels of arousal/activation as induced by postural changes and exercise on reaction time (RT) for the young and old at different fitness levels. Woods found a significant interaction between age and posture whereby older subjects performed significantly better when standing on a two-choice RT task than when lying or sitting. For both simple and two-choice visual RT, no posture effects were found for the young subjects. She concluded that older adults may function in a state of underarousal in comparison with the younger individuals and that by increasing the level of arousal through posture changes (lying to sitting to standing) presumably the primary posture processing speed increases.

A mediating variable with regard to RT is the ascending Reticular Activating System (RAS), and is thought to be responsible for maintaining a state of arousal and certain attentional processes. Isaac (1960) found that stimulating the RAS through increased sensory input or electrical impulses generally improved RT. Stimulation of the RAS has also been linked to improved cognitive functioning. Increases in arousal have thus been linked to improvement in performance on psychophysically-oriented tasks. While standing stimulates the RAS more than lying or sitting, posture becomes a variable which could be used to resolve the CNS underarousal versus overarousal debate as in the Woods study.

Another study examining posture effects and RT with regard to the RAS was done by Diggles and Grabiner (1984). This experiment used a tilt-table to rotate subjects from right-side up to up-side down while also testing RT. The results showed no significant main effect from postural orientation, which appears to refute claims of the robustness of the posture effects on RT. This study may indicate however, that the posture effect may have more of an influence on specific stages of information processing, rather than a more generalized effect.
Modeling Cognitive Stages of Information Processing

Several experiments have examined the structural stages of information processing, many using the Additive Factors Method (AFM) (Sternberg, 1969). The AFM assumes information is processed independently through serial stages, each requiring some time for processing, thereby making the overall reaction time a sum of the individual processing times for each stage. If task manipulation affects one stage, the overall reaction time will be longer as a result. Significant interactions between independent variables indicates that the task manipulations are not affecting individual component stages but are exhibiting an influence on reaction time at one, or more, common stages (e.g.,

![Diagram of information processing stages](image)

Figure 1. Working model of information processing and human performance (adapted from Mulder, 1986; Pribram & McGuinness, 1975; Sanders, 1983; Vercruysse, 1984, in press).

(Sanders, 1977, 1980, 1983; Sternberg, 1969; Vercruysse, 1984). (See Figure 1) However, additive results suggest two or more intratask manipulations are each affecting different stages. Thus the AFM uses multi-factor analysis of variance to determine which intratask variables can be used to specifically load a stage of information processing (e.g., stimulus quality affects encoding, stimulus-response compatibility affects response selection).

While most stage modeling studies have used young adults, few have examined the effects of age on CNS processing stages. Salthouse and Somberg (1982), using the AFM, included three intratask manipulations: stimulus degradation, response type, and comparison set size. The results found main effects of the intratask manipulations and age as well as interactions of each intratask manipulation with age leading them to the conclusion that age-related behavioral slowing of a response was general in nature and may reflect an overall speed reduction in central nervous system activity. However, this experiment also yielded a significant interaction between the intratask manipulations themselves which complicates the issue somewhat since failure to select intratask factors which are
independent limits our ability to make inferences about effects on stages of information processing. The intratask factors must be additive before administering the stressor (e.g., Sanders, 1980; Vercruysse, 1984).

Also, a study done by Simon and Pouraghabaghi (1978) used two intratask manipulations using a two choice RT task to ascertain the locus of slowing. The first involved stimulus quality and the second manipulated the direction of a cue to affect response selection. The results showed a significant interaction between stimulus quality and age such that there were greater differences between young and old when the stimulus was degraded, thereby leading the authors to conclude that the locus of age-related slowing was central, not peripheral, specific in nature, rather than general, and impacted the earlier, stimulus encoding stage of processing. However, failing to find main effects of the directional cue questions the validity of this intratask manipulation to serve as a measure reflecting activity in a particular stage of processing, and hence, may not be applicable within the framework of the AFM.

Posture and Cognitive Stages

Only two studies have been done in the area of posture and stages of information processing. One experiment by Vercruysse, Cann, and Hancock (1989) looked at all these factors. Posture was manipulated and low S-R compatibility used to determine if there was an effect on the various stages of processing. They found that gender, degradation, and posture interact to indicate that men benefit more from posture effects on the degraded task than on the intact. Also found was that there may be gender differences in information processing such that the females may be faster on tasks which load early stages of processing. The other study was done by Cann (1990ab) and analyzed the effects of age, gender, posture-induced arousal, task loading, task difficulty, and length of response-stimulus interval. He found that the benefits of posture are related to task difficulty in that postural stimulation benefits performance most during tasks of relatively moderate difficulty. In addition, he concluded that older subjects may become overaroused more easily than younger subjects, thereby causing performance decrement. It is clear that there is still much research to be done in this area, but for now the initial findings from this research provide a basis for further research to follow.

PRELIMINARY RESULTS ON TWO EXPERIMENTS

Experiment 1: Age, Arousal, and Information Processing

In an attempt to replicate Woods' (1981), the purpose of this experiment was to determine the effects of age and posture on information processing as measured by reaction time.

Method. To date four groups of healthy volunteer including 12 older men, 12 older women, 28 younger men, and 28 younger women were recruited for this experiment. Analysis has been conducted on 4 older men, 4 older women, 8 younger men, and 8 younger women. The older subjects were obtained from university faculty, non-traditional students, and active senior citizen groups and can be considered above average in level of mental and physical functioning for their age groups.

Subjects were presented visual stimuli on a computer monitor which consisted of arrows pointing either left or right. The subject responded by pressing microswitches placed beneath the index and middle fingers of each hand, which corresponded to the direction the arrow is pointing.

The independent variables in the study were: (1) sex—male vs. female; (2) posture—sit vs. stand; (3) intact or degraded stimulus; (4) S-R compatibility performed with two levels: high and low; (5) variable choice reaction time and serial choice reaction time; and (6) two days.

Each subject performed some 3500 RT trials divided equally amongst the various conditions and over two days of testing. Each day the subject had practice trials to familiarize them with the nature of the tasks. The subjects were instructed to keep their fingers rested lightly on the microswitches and react as quickly as possible while maintaining a 5% error rate in order to ensure in the data that there is not a speed accuracy trade off.

Results. The preliminary results show older adults to react significantly slower than the young adults regardless of the stimulus quality. Also, we found that the older adults react slower when seated than standing but for the younger adults, this interaction disappeared on Day 2. In conclusion, preliminary results support the hypothesis that the older nervous system appears to be underaroused when compared to the young when performing visual reaction time tasks.
Experiment 2: Gender Differences in Posture Effects on RT

Having investigated the age effect, next important are gender differences in mental performance. The existence of gender differences on tasks emphasizing rapid response has been a point of contention within psychomotor literature for several decades. While some studies have concluded that men are faster than women (Bell, Loomis & Cervonne, 1982; Coles, Porges, & Duncan-Johnson, 1975; Ferguson, 1974; Henry, 1960; Hodgkins, 1953; Lahtela, Niemi, & Kuusela, 1983; Noble, Baker, & Jones, 1964; Teichner, 1954), others have advocated the opposite point of view (Fulton & Hubbard, 1975; Thomas & French, 1985). Still others have failed to find any gender-related differences in reaction time whatsoever (Almirall & Gutierrez, 1987; Murphy-Berman & Wright, 1987; Yandell & Spirduso, 1981). Despite the generally equivocal findings that exist in the literature, it seems that the weight of the experimental evidence indicates that men react faster than do women.

Several variables have been identified as interacting with gender on RT tasks. However, the locus of effect of these variables within the information processing system is not well understood. Therefore, the purpose of this research is: 1) to identify gender and posture differences in speed of behavior, and 2) using the additive factors methodology, to determine whether observed effects are of a general nature, affecting all stages of processing, or specific, differentially affecting one or more stages of information processing.

Method. Collected to date are 56 healthy recruited volunteers between the ages of 18 and 43, but to date analysis has been done on 28 (14 females and 14 males). All subjects were drawn from the college population and community and are considered to be functioning at comparable intellectual and physical levels. All the same variables were manipulated as in the first experiment except the low compatibility condition was omitted, reducing the number of trials to approximately 1600.

Results. Although these results are preliminary, it gives an idea of what we are finding. Analyses were conducted and an interaction between gender and degradation revealed for SCRT that females were faster than males; while on the intact task there was little difference between the speed of females and males. Also, a three way interaction was revealed on SCRT between the factors of gender, degradation, and posture. While the females performed faster when standing on the intact and degraded tasks to an equal extent, the males benefited more from standing on the degraded task than on the intact.

In conclusion, it appears that females may have an advantage over males on tasks emphasizing early stages of processing, particularly when feature extraction skills are required. However, this effect disappears when subjects stand. Also, depending on one’s perspective, this study supports both the positions that females are faster than males and that there are no gender differences in RT.

CONCLUSIONS

A literature review indicates posture does affect mental performance and information processing. It also seems to show that exercise, and stimulation of the RAS and CNS in general, may decrease or greatly reduce the amount of behavioral slowing that seems to occur with advancing age. In reviewing preliminary results of previous experiments, it appears that the elderly do benefit from postural manipulations of arousal, as well as there being sex differences in the speed and stages of information processing. Previously unknown were the implications to NASA and the human operators of telerobotics. However the research and review seem to indicate that posture may in fact have an effect on the elder operator and his or her performance. Also, the sex differences in the stages of information processing and speed of response may help NASA when selecting an operator for a particular task. This research will be continued and to follow will be the data analysis on the additional subjects that have been collected.

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