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ORIGINAL ARTICLE

Examining the Influence of Different Attentional Demands and Individuals' Cognitive Failure on Workload Assessment and Psychological Functioning

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ABSTRACT

Attentional demands and individuals' cognitive failure are hypothesized to be determinant factors for workload assessment and job analysis, although previous researches have focused merely on one aspect of attentional demands. The objective of this study was to investigate the degree to which various attentional paradigms would be demanding to the participants with different levels of cognitive failure. A total of 24 participants within three groups of low, medium, and high cognitive failure questionnaire (CFQ) scorers completed two 15-min and one 60-min tasks representing three paradigms of "divided", "selective", and "sustained" attention. The participants were undergraduate male students from the University of UOEH, Japan. Outcomes were measured in subjective workload, stress-arousal and anxiety level, along with performance measures. Accordingly, MANOVA and Post Hoc Tukey-test analyses between variables showed that the divided attention task created a higher workload with a better arousal level, while an increased level of frustration with a decreased level of arousal was induced by the sustained attention task. Confirming the proposed model of cognitive failure in this study, greater workload with worse psychological functioning and performance breakdown was found among the high CFQ scorers. These findings have important implications for conducting workload analysis researches in real-world or laboratory settings; focusing on attentional demand and cognitive failure may be an effective way to alleviate stress.

Keywords: *Attentional demand, Cognitive failure, CFQ, Stress, Arousal, Workload*

INTRODUCTION

Attentional demand

A critical aspect of designing systems for the dynamic or static work situations is the amount of visual and cognitive attention required to complete a task, which is termed "attention demand" [1]. In dynamic environments like driving, piloting, control room operating, industrial inspection and medical monitoring, the safety and health aspects of attention demand are paramount, as failing to adequately address attention demand issues in those jobs may lead to poor usability, user confusion, and loss of revenue [1, 2]. For static environments such as desktop computing and VDT works, attention demand is more important for usability issues than for safety issues.

Considering the resource theory of the attention, different aspects of attention may be investigated with three main paradigms [2, 3]: (a) *Selective attention*, in which participants must respond to the same stimuli, or stimulus properties, whilst ignoring others; (b) *Divided attention*, in which participants must perform two (or more) tasks simultaneously, such as driving and flying; and (c) *Sustained attention*, in which participants must maintain the focus of attention over a relatively long

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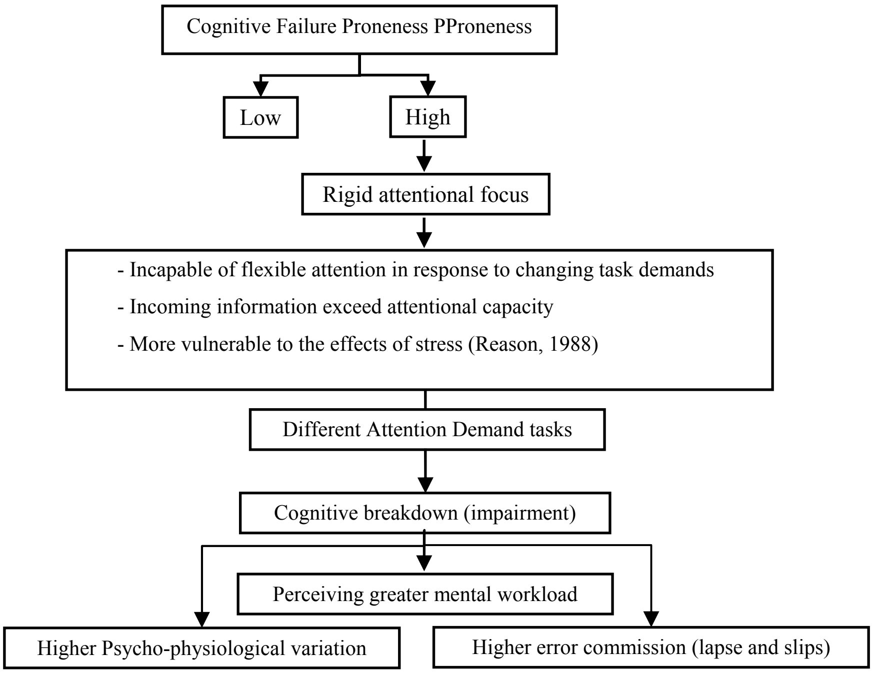


Fig 1. Model showing the impact of cognitive failure on task performance, perceived workload and psychological functions.

time-period, as in industrial inspection, air traffic control, and medical monitoring.

Each attentional paradigm induces a different level of mental workload [2, 3]. Kantowitz [4] has proposed a model to explain possible relationships between attention and mental workload within different configurations and he finally considered workload as a subset of attention. Therefore, realizing the role of attentional demand on mental workload and psychological functioning would make a new prospective in workload assessment, job analysis, and work design. However, there is no or little study comparing the level of workload or psychological functioning between those attentional demands.

Cognitive failure

Cognitive failure has been described as a breakdown in cognitive functioning which results in mistake or error in task execution that a person should normally be capable of completing, with some people being more prone to experiencing cognitive failure than others [5, 6]. Martin (1983) has mentioned some reasons for the necessity of studying cognitive failure. For certain dangerous tasks such as flying, the occurrence of cognitive failure can have serious effects [5]. In addition, individuals with higher cognitive failures are susceptible to the adverse psychological effects of a high-stress environment. Further, analysis of the types of cognitive failures that commonly occur may shed light on the way in which higher order mental functions are organized. Therefore, attempts have made to develop self-report measures of information processing abilities, of which probably the best known is the 25-item Cognitive Failure Questionnaire (CFQ) [7]. It is an index of the efficiency for distributing attention over multiple inputs under stressful conditions [4].

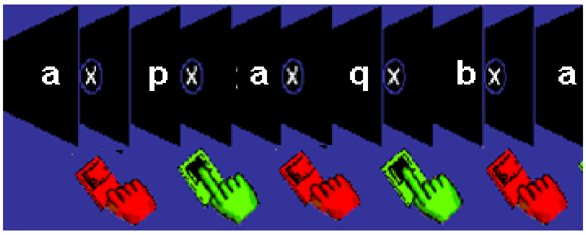
Fig. 1 illustrates the impact of cognitive failure on attentional focus and performance breakdowns. This model was proposed by the authors in this study on the basis of Reason's premise [8]. According to this model, people prone to cognitive failure might have a rigid attentional focus, thereby creating a cognitive management style that might allow for the occurrence of cognitive breakdowns in dealing with intervening and concurrent stimuli.

In sum, previous studies related to attention demands have concentrated merely on one aspect of attention, either sustained, divided, or selective attention. Yet, studying various paradigms of attentional demand within a comparative framework would give a new perspective on workload assessments and job analyses in real-world and laboratory applications. To address the need for more empirical data in this area, the current study was designed to examine the level of workload and stress is induced by various cognitive tasks requiring different attentional paradigms. Furthermore, the influence of individuals' cognitive failure on subjective and objective outcomes was probed while performing each task.

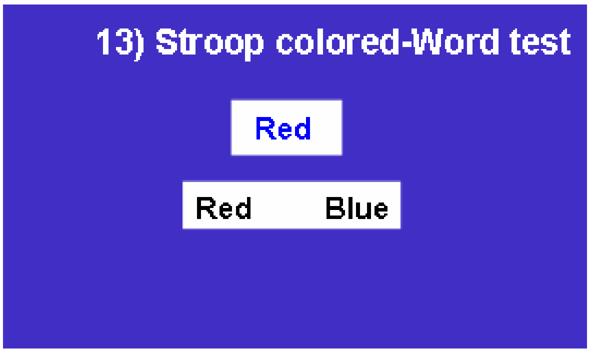
MATERIALS AND METHODS

Design and procedure

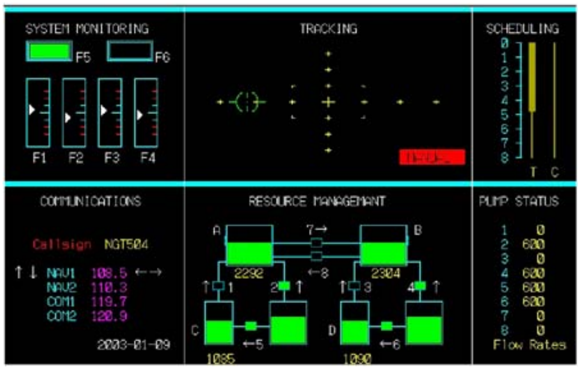
A 3×3 full factorial experiment was designed to test the effects of three levels of attentional demand and cognitive failure on perceived workload, psychological functioning, and task performance variables. A total of 24 participants conducted three kinds of cognitive tasks within three groups of low, medium, and high scorers (8 people in each group) in a random base. The selective and divided attention tasks were of 15 minutes duration



(a): Sustained Attention Response Test



(b): Stroop Test



(c): Multi-Attributed Battery Task

Fig 2. Screenshots for utilized cognitive tasks.

along with a 60-minute period for the sustained attention task. All trials were separated by 5-minute breaks.

The participants were screened from 120 volunteers who had initially responded to the first call of the study. For a test-retest reliability of the CFQ, it was administered twice by the participants with approximately one month in between. In addition, a written informed consent was obtained from all participants following a detailed briefing on the purpose of the experiment. Then, after completing a demographic and medical questionnaire, a practice session was given to get familiar with each task and adaptation to the experimental condition. Next, before beginning the experimental session, they were given a 10-minute time to be relaxed and to complete SCAL and STAI checklists. After that, the participants were assigned to complete the tasks during the allocated time. They completed the NASA-TLX, STAI, and SACL questionnaires during the 5-minute breaks.

Participants

In all, twenty-four undergraduate male students (aged, M=22.71, SD=1.16) were recruited as participants from the University of Occupational and Environmental Health, Japan. They had no history of or current conditions that would affect their perceptual, cognitive, or motor functions during manipulation of the tasks in general, and they were required to have normal or corrected-to-normal vision, have had sufficient sleep the night before the experiment and have abstained from drinking alcohol.

Independent variables

Attentional demand (selective, divided, and sustained attention) and individuals' cognitive failure were two independent variables in present study. The Japanese version of the CFQ [9] was used to determine participants' cognitive failure. It contained 25 items that cover failures of perception, memory, and motor function. Respondents indicated for each question the frequency with which that type of cognitive failure had occurred to them during the previous 6 months, on a 5-point scale ranging from "never" (0) to "very often" (4).

Tasks

Three attentional paradigms (selective, divided, and sustained attention) were presented utilizing three specific tasks as below:

The Sustained Attention Response Test (SART) was constructed as 'go and no-go' Roman alphabet stimuli (Fig. 2a) similar to the standard type of vigilance task developed by Robertson, Manly et al. (1997) [10]. The subjects were instructed to respond to the target letters 'p' or 'q' by clicking the mouse and not to respond to the other letters as non-target stimuli by withholding clicking the mouse. The event rate (number of displays) was updated 30-40 times per minute on an irregular basis with an exposure time of 300 msec. Signal probability (detecting target signal) was set up at 5 percent, which is considered a low probability rate [3].

The Stroop Color Word Test (SCWT): It is a psychological test of mental (attentional) vitality and flexibility taking the advantage of our ability to read words more quickly and automatically than we can name colors. The cognitive mechanism involved in this task is called selected attention [3, 11]. In this task, the participants had to manage their attention, inhibit or stop one response in order to say or do something else (Fig. 2b).

The Multi-Attribute Task Battery (MATB): A revised version of the Multi-Attribute Task Battery was used for divided attention demand [12]. It consisted of a two-dimensional tracking (fig 2c; top center),

Table 1. Mean (SE) of the subjective measures for each of the cognitive task (n = 24)

	Task Type				MANOVA	
Variables	Pre-study	SCWT	MATB	SART	F	*P*
		Subjective evaluation of workload (NASA-TLX)				
AWWL	N/A	55.73 (3.1)	80.38 (3.61)	70.67 (3.51)	13.64	> 0.001
R-TLX	N/A	43.861 (3.29)	68.451 (3.67)	60.61 (3.62)	12.97	> 0.001
Mental demand	N/A	48.84 (6.23)	84.12 (3.56)	64.83 (7.34)	9.42	> 0.001
Physical demand	N/A	18.86 (4.69)	67.87 (6.14)	34.78 (7.54)	16.94	> 0.001
Temporal demand	N/A	52.15 (6.31)	59.01 (7.36)	62.33 (6.81)	0.57	0.57
Performance	N/A	42.51 (4.43)	59.04 (6.54)	58.97 (5.07)	3.1	0.58
Effort	N/A	64.76 (4.98)	87.05 (4.38)	73.04 (5.35)	5.45	0.006
Frustration	N/A	36.05 (4.54)	53.65 (6.81)	69.79 (5.65)	8.48	0.001
		Stress Arousal Scale (SACL)				
Stress level	3.39 (0.66)	5.12 (1.11)	6.59 (1.14)	8.13 (0.89)	4.49	0.006
Arousal level	4.39 (0.75)	5.76 (0.54)	6.35 (0.58)	3.06 (0.35)	5.07	0.003
		State Trait Anxiety Inventory (STAI)				
State Anxiety	35.5 (1.54)	36.04 (2.01)	41 (2.68)	41.3 (2.92)	2.22	0.094

AWWL = Adaptive Weighted Work Load; R-TLX = Raw overall score; SCWT = Stroop Color Word Test; MATB = Multi-Attribute Task Battery; SART = Sustained Attention Response Test; N/A= Not Applicable.

monitoring (fig 2c; top left) and fuel management (Fig. 2c; bottom center) tasks. Participants were instructed to keep fuel levels of four tanks above specific fuel levels (2,000 for tanks A and B; 1,000 for tanks C and D) in the fuel management task.

Dependent variables

Subjective workload assessment: The abridged Japanese version of the NASA-TLX inventory was applied for this assessment [13]. The ratings consisted of six component scales: mental, physical, and temporal demands, performance, effort, and frustration level. The subjects rated their subjective workload on six 10-cm visual-analog scale. Average Weighted Workload (WWL) is usually computed as overall score by paired-comparison method of the six-component scores. But, this method could have been somewhat cumbersome and complex to the participants, although they were undergraduate medical students. Therefore, we used 'Adaptive Weighted Workload (AWWL)' instead, to simplify and facilitate this procedure. Its validity in younger adults has been reported by Miyake and Kumashiro (1993) [14].

Stress and arousal level: This evaluation was conducted using the Stress Arousal Checklist (SACL) [15]. It consisted of 30-item adjective checklist, seventeen related to the stress scale, reflecting individual perceived preference about physical and psychological conditions, and thirteen related to the arousal scale, reflecting physical activities, especially autonomic nervous activity. Respondents indicated on a four point scale how accurately each adjective matches their current state. Possible scores ranged from 0 to 17 for stress and 0 to 13 for arousal, with higher scores indicating greater stress or arousal.

Anxiety level: The State-Trait Anxiety Inventory (STAI) was used for this mean [16]. The state-anxiety scale consisted of twenty statements that evaluate how respondents feel "right now, at this moment." Individuals respond to each item on a four-point Likert scale ranged from (1) not at al to (4) very much so. Scores on the STAI have a direct interpretation: high scores on their respective scales mean more psychological stress and state anxiety and low scores mean less.

Performance-related variables: Concerning sustained attention task, performance measures included: (I) response time, which was the time lapse between the first appearance of each target letter and clicking a mouse by the participants, and (II) correct detection, which was the number of correct answers divided by the total number of answers. For selective attention task, two independent variables were defined: (I) response time, which included the time lapse between the first appearance of a color or name stimulus and clicking of the mouse, and (II) accuracy rate, which was calculated as the number of correct answers divided by the total number of answers. Considering the divided attention task, (I) reaction time for significant deviations in the four vertical gauges in the monitoring task, and (II) average of fuel levels of tanks A, B, C, and D (sum of these four tanks) in the fuel management and (III) RMSE (root mean squared error) in the tracking tasks were recorded during task implementation.

Data analysis

A multivariate analysis of variance (MANOVA) was used to test the statistical differences of the dependent variables based on the independent variables (type of tasks and CFQ scores). Furthermore, Post Hoc tests (Tukey HSD) were used to determine specific differences between levels for any dependent variables that showed statistical significance. Based on the participants' CFQ score they were split into three groups of low (>25), medium (26-40), and high (<41) scorers and statistical analyses and comparisons were made between these groups with a 5% significant level in all tests.

RESULTS

Table 1 shows the overall scores of the NASA-TLX based on the three types of attentional demand tasks. The participants did perceive the divided attention task to be more demanding than the selective or sustained attention task (F (2, 69) = 13.64, p < 0.001). Specifically, except for temporal demand and performance (F (2, 69) = 0.57, p = 0.57; F (2, 69) = 3.1, p = 0.58), they showed significant differences in mental and physical demand, effort and frustration. Wherein, they experienced an increased level of mental and physical demand (F (2, 69) = 9.42, p > 0.001; F (2, 69) = 16.94, p > 0.001) and a high level of effort (F (2, 69) = 5.45, p = 0.006) when performing the divided attention task. On the other hand, the sustained attention task was more frustrating (F (2, 69) = 8.48, p = 0.001) and mentally demanding (F (2, 69) = 9.42, p = 0.001) to the participants. Finally, subjective measures indicated that the selective attention task was less demanding in all subscale scores of the NASA-TLX compared to the divided and sustained attention tasks.

Analyzing the result of the stress arousal checklist indicated that performing the sustained attention task created an increased level of stress (F (3, 68) = 4.49, p = 0.006) and a decreased level of arousal (F (3, 68) = 5.07, p = 0.003) compared to the psychological state of the participants in the pre-study stage. Nonetheless, the MANOVA test showed no significant differences in state anxiety level of the participants between the tasks and the baseline levels (F (3, 68) = 2.22, p = 0.094).

A higher correlation (r=0.89) of the test-retest reliability was observed between the first and the second responses of the participants. The mean of CFQ total score (sum of responses on 25 items) was 38.92 with a standard deviation of 15.79 and a range of 12–65. Table 2 shows a summary of the mean scores for the dependent variables among the three groups of the CFQ scorers. The ANOVA test revealed that the sustained attention task was more demanding to the individuals with a high CFQ score than to the low and medium scorers, indicated only by the overall and mental demand scores (AWWL, F (2, 21) = 4.89, p = 0. 019; R-TLX, F (2, 21) = 7.46, p = 0.004; and mental demand, F (2, 21) = 8.19, p = 0. 003). Likewise, the high score groups did perceive the divided attention task to be more challenging (AWWL, F (2, 21) = 3.48, p = 0. 047), although none of the subscale scores were significantly different concerning this task.

In addition, from the result of this study, significant differences in stress and arousal level as measured by SACL were identified between the CFQ groups undertaking the three different kinds of cognitive tasks. In this case, Post Hoc tests revealed an increased level of stress and anxiety for the high scorers when they performed the divided attention task (Tukey HSD, p = 0. 025; p = 0. 049) rather than the low scorers. But neither the stress, arousal, or sate anxiety level significantly differed between those groups when performing either the sustained attention or the selective attention task.

Furthermore, as shown in table 3, mean differences of the performance measures were also analyzed between the three levels of CFQ scorers. As a result, the high score participants showed a decreased level of accuracy F (2, 21) = 9.49, p = 0. 05 when they were assigned to reply the name in different color (incongruent stage of the Stroop test) in the selective attention task, even though they carried out the task more slowly than in the congruent (just name or color) stages (F (2, 21) = 5.49, p = 0. 018). But, in terms of the sustained attention task, applying the MANOVA test indicated no significant differences in response time or correct detection rate between the CFQ groups (F (2, 20) = 1.43, p = 0. 28; F (2, 20) = 2.92, p = 0.5). On the other hand, individual cognitive failure was a determinant factor for performance variations in the divided attention task. In this case, low score individuals could manage the task easier with better performance than the high scorers. This group also showed less omission rate F (2, 20) = 4.28, p = 0. 019), with a shorter response time F (2, 20) = 3.78, p = 0. 05). Furthermore, the fuel level was significantly higher in the low score group than in the high score group F (2, 20) = 3.56, p = 0. 032). But no significant differences were found for the RMSE changes between the groups.

DISCUSSION

The intention in this study was to put participants into three types of the work situations, each of which required a different kind of attention demand, and then to evaluate the level of workload and stress imposed on them through manipulation of those tasks. The findings showed that the three types of attentional demand resulted in different patterns of subjective workload and psychological functioning. In addition, individuals' cognitive failure was found to be a determinant factor, to some extent, for variations in the subjective and objective measures.

Among the tasks utilized in this study, participants did perceive the divided attention task as the most demanding task rather than the sustained or selective attention tasks. Specifically, the highest rate of effort, mental and physical demand in this task might mirror a greater amount of resource investment expended by the individuals. The MATB task is a multi-complex task, which consists of tracking, monitoring, and fuel management tasks. It is assumed that monitoring the target stimulus and fuel management of the MATB task along with controlling the tracking task imposed a more-or-less continuous demand on attention [3]. However, one might question that these differences might be due to higher task demand rather than attentioanl demand. To explain this, O'Donnell & Eggemeier (1986) have mentioned that the concept of mental workload, analogous to physical workload, had been developed to refer to the attentional demands experienced during the performance of a cognitive task

Table 2. Mean (SE) of the subjective measures for each of the CFQ group scorers and cognitive task (n = 24)

	SCWT			MATB			SART		
Variables	Low scorer	Medium scorer	High scorer	Low scorer	Medium scorer	High scorer	Low scorer	Medium scorer	High scorer
				Subjective evaluation of workload (NASA-TLX)					
AWWL	53.92	57.082	56.19	78.52	71.59	91.052*	57.03	70.82	80.75*
	(5.7)	(4.74)	(6.25)	(5.54)	(6.25)	(5.55)	(4.66)	(4.86)	(5.62)
R-TLX	37.87	47.31	46.39	64.08	62.68	78.58	44.98	60.13	72.84*
	(6.48)	(4.67)	(5.97)	(5.86)	(6.95)	(5.32)	(3.62)	(4.22)	(5.97)
Mental demand	43.12	50.21	53.18	77.43	86.02	88.87	27.82	75.1	82.3*
	(12.79)	(7.12)	(12.66)	(7.01)	(5.25)	(6.16)	(8.86)	(10.03)	(9.78)
Physical demand	9.11	24.15	23.31	66.31	59.11	78.17	12.85	32.73	53.28
	(6.23)	(7.45)	(10.09)	(10.84)	(12.5)	(8.35)	(6.95)	(12.79)	(13.36)
Temporal demand	42.47	59.11	54.87	54.76	52.33	69.92	46.61	64.19	72.25
	(10.99)	(10.37)	(11.89)	(13.76)	(11.31)	(13.79)	(14.36)	(12.88)	(8.06)
Performance	47.24	44.27	36.01	55.29	53.38	68.43	56.21	52.22	67.79
	(3.01)	(8.75)	(9.93)	(9.83)	(13.08)	(11.6)	(7.64)	(10.74)	(6.85)
Effort	65.78	62.39	66.1	88.35	74.89	97.88	68.22	69.49	80.19
	(10.63)	(9.7)	(6.1)	(3.72)	(11.64)	(1.097)	(12.47)	(7.68)	(9.05)
Frustration	19.49	43.75	44.91	42.37	50.34	68.22	58.19	67.04	81.25
	(7.68)	(6.71)	(6.34)	(10.32)	(11.9)	(12.6)	(6.6)	(11.5)	(8.53)
				Stress Arousal Scale (SACL)					
Stress level	2.8	4.6	7.14	2.8	8.14	8.2*	7.5	6.8	9.42
	(0.73)	(2.33)	(1.89)	(1.24)	(1.63)	(2.35)	(1.5)	(1.28)	(1.62)
Arousal level	5.6	6.2	5.57	6.6	7.6	5.28	3.25	2.8	3.142
	(0.6	(1.2	(0.99)	(1.16)	(1.03)	(0.8)	(0.85)	(0.66)	(0.50)
				State Trait Anxiety Inventory (STAI)					
State Anxiety	31.75	37.125	39.25	33.75	41.13	49.14*	35.5	42.75	46.28
	(1.54)	(2.03)	(5.39)	(1.95)	(4.03)	(6.21)	(5.93)	(3.52)	(5.29)

*$P < 0.05$; AWWL = Adaptive Weighted Work Load; R-TLX = Raw overall score; SCWT = Stroop Color Word Test; MATB = Multi-Attribute Task Battery; CRT = Sustained Attention Response Test; CFQ = Cognitive Failure Questionnaire.

[17]. As noted in the outset of this study, this is consistent to the model proposed by Kantowitz (2000) who considered workload as a subset of attention [4]. Moreover, it may refer to people's experiences of cognitive task performance as effortful and fatiguing, which may index task demands or attentional overload [3]. In this task, participants were instructed to control all three displays simultaneously while they maintained the level of performance in an optimal level. These requirements might lead the participants to a higher state of capacity expenditure and showing higher level of workload, as a result. This is in line with the fact that maintenance of performance is achieved at the cost of greater effort/capacity expenditure, and this is reflected in the subjective workload ratings [18].

Subjective workload was also shown higher when the participants undertaking the sustained attention task. We supposed that vigilance task might be unstimulating task, in which observers have little to do as comparing to the divided and selective attention tasks. But, many previous studies suggest that vigilance tasks are rated as highly demanding tasks [18, 19]. One plausible reason for this might be the boring effect of vigilance task on participants' psychological state. Matthews et al. (2000) [3] concluded that the subject performing a vigilance task is not in a passive, mindless state, but is attempting to cope actively with a state of growing emotional and cognitive disturbance. Indeed, high workload appears to be one of the main drivers of distress in a performance setting. On the other hand, as mentioned by Helton et. al. (2005) [20]; and Broadbent et al. (1986) [21], the greater workload observed here might also be rooted in the information-processing demands of the vigilance task itself, rather than being only a consequence of combating the boredom associated with the task. In present study, participants evaluated the sustained attention task as a highly mentally demanding and frustrating task, unlike that of the divided attention task. This is consistent with Warm et al. (1996) conclusion that the cost of mental operations in vigilance is substantial, with mental demand and frustration as primary contributors [18].

For vigilance task, arousal level was also more adverse than that of the divided attention task in this study. This might be explained by the "arousal theory" on sustained attention task in which prolonged task performance leads to a lowering of central nervous system arousal or activation. On the contrary, the higher arousal level for the divided attention task might be explained by Kahneman's (1973) theory of attention [22]. According to this theory, the level of physiological arousal varies with the amount of cognitive resources

Table 3. Means (SE) of the performance-related measures for each group of the CFQ scorers (n=24)

	CFQ Group			MANOVA	
Variable	Low scorer	Medium scorer	High scorer	F	*P*
Stroop Color Word Test (SCWT)					
Accuracy Rate	96.03 (1.44)	92.66 (1.9)	95.14 (1.32)	9.49	0.05
Reaction time	749.25 (37.73)	745.5 (38.19)	811.38 (37.64)	5.49	0.018
Multi Attribute Battery Test (MATB)					
Response time	1.58 (0.26)	1.7(0.086)	2.19 (0.49)	3.78	0.05
Omission rate	1.63 (0.84)	2.75 (2.34)	2.71 (0.84)	4.28	0.019
Fuel level	1653 (70.89)	1837 (62.47)	1749 (53.06)	3.56	0.032
Sustained Attention Response Test (SART)					
Response time	539.61(18.39)	485.57 (17.31)	532.92 (12.46)	1.43	0.28
Correct detection	99.45 (0.12)	99.69 (0.1)	99.8 (0.04)	2.92	0.5

CFQ = Cognitive failure questionnaire

that has to be recruited for task-specific purposes. Further, recruitment of resources is equated with exertion of mental effort and the intensive aspects of attention. In general, the more difficult a task is, the greater the amount of resources that have to be recruited and the greater the amount of arousal.

Considering the participants' cognitive failure, the high CFQ individuals generally perceived the assigned tasks much more challenging than did the low scorers. This supports the cognitive model proposed in the present study. Previous studies also support that mental workload is perceived as greater for individuals obtaining high than for those obtaining low CFQ scores, even though performance scores may be much the same for the two groups [18, 23].

Comparing the CFQ groups yielded no significant differences either in stress and arousal state or in anxiety level when performing the sustained attention task; although the high scorers showed an increased sense of overall and mental workload than that of the low or medium groups. This is in conflict with the underlying concepts of the cognitive failure model (fig 1). Based on this model, if the task demand change or incoming information exceeds the attentional capacity, cognitive failure may play a role in performance breakdown, vulnerability to inducing stress from the task performance and physiological variations. This might be due to the nature of each task utilized in the present study. As suggested by Martin (1983), it is possible in principle that cognitive failures arise from difficulties in distributing rather than in focusing attention [5]. Furthermore, as shown in the cognitive failure model here, the high CFQ scores may reflect a cognitive management style of inflexible attentional focus. Such inflexibility could leave concurrent activities unmonitored and thereby susceptible to breakdowns or errors. But, Houston (1989) explained it by the over-monitoring hypothesis in which individuals scoring highly on the CFQ are particularly aware of their propensity to make errors and, in task situations when external demands are high, self-focusing impairs their performance and psychological functioning [24].

Selective attention was another aspect of the attentional paradigm which created a significant longer latency with a lower accuracy rate among high score individuals, although a significant correlation was observed neither in the subjective workload nor in the stress-arousal and anxiety level. These data actually support the hypothesis that the CFQ score may predict the efficiency of selective attention. Tipper et al. (1987) have shown a same conclusion in their study on "individual differences in selective attention" [11]. In contrast, Martin (1983) found no correlation between CFQ score and the degree of interference in the same Stroop task that was used in this study [5]. He latter suggested a difference between the mechanism of interference and priming in Stroop tasks.

Limitations

Part of the data was collected via the use of self-report data and may be biased. However, the results of performance measures support the use of the self-report data on workload and psychological assessments. We selected a relatively homogenous population of undergraduate male students with the age ranging from 19 to 24 years old to serve as subjects in this experiment. This selection reduces potential confounding effects such as aging, cognitive ability and processing speed. It would be important for subsequent research to collect data on actual employee performance data in order to gain a more precise assessment of the attentional demand-cognitive failure relationship. Therefore, further research would be needed before making an attempt to broaden these results to a larger population.

CONCLUSION

The present study indicated that different paradigms of attentional demand can create various levels of subjective workload and stresses. Specifically, the highest rate of perceived workload for the divided attention task and the increased sense of frustration with the decreased level of arousal for sustained attention were remarkable patterns as the main characteristics observed in the current study. Furthermore, individuals' cognitive failure had a determinant effect on both perceived workload and performance measures.

In conclusion, the investigation of workload on the basis of attentional paradigms would make a new perspective in real-world and laboratory applications and may have important implications for researches conducting workload and job analysis research. Further, focusing on attentional demand and cognitive failure may be an effective way to alleviate stress. Considering individuals' cognitive failure with the purpose of choosing between operators (low CFQ score individuals) or providing an operator with further training would be an empirical approach to reduce operators' workload and to improve their performance. These practices could finally help to decrease the frequency of on-the-job accidents and injuries. It is hoped that the findings of the present study are a step in that direction.

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