Examination of Cognitive Function of Female College Students with High CFQ Scores Using a Stroop Test

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ABSTRACT

Purpose: To examine behavior characteristics of individuals with high CFQ scores in a Stroop test.

Method: Twenty-nine individuals with high (H) and low (L) CFQ scores were selected from 225 female students at Y University and underwent a Stroop test.

Results: 1) Regarding reaction time for the Stroop test: the reaction time slowed as the rate of agreement decreased for the CFQ H group compared to the CFQ L group.
2) Regarding the number of errors for the Stroop test: the number of errors increased as the rate of agreement decreased for the CFQ H group compared to the CFQ L group.
3) Regarding the psychological state of the CFQ H group and CFQ L group during task performance for the Stroop test: the CFQ H group had a greater sense of being pressed for time compared to the CFQ L group.

Our results suggest that when individuals with high CFQ scores run into a time-critical situation, a physical factor, task reaction time will slow and errors will increase.

Key words: Stroop test, CFQ, cognitive function, behavior characteristics, physical factor

INTRODUCTION

Causes of mishaps in medical practice are classified as physical factors and human factors. Time-related urgency and a large amount of work and the severity of the patient, the urgency of the situation and time, temperature and relative humidity, illumination, shift operations, and personal relationships, are cited as physical factors. Mistakes in recognition or confirmation and misjudgment, educational background and years of service, a lack of...
knowledge and a lack of skill, fatigue and drowsiness, behavior characteristics, have been reported as human factors.

The authors have focused on human factors for causes of mishaps in medical practice; as a result of a survey on the relationship with needle stick accidents using the Cognitive Failures Questionnaire (CFQ), a questionnaire expressing the frequency of failure in everyday life, a significant relationship between individuals with high CFQ scores and the presence or absence of needle stick accidents was noted.

In a test using visual search tasks, individuals with high CFQ scores were more susceptible to inappropriate information from the outside world; the presence of vulnerability in cognitive function was suggested.

The CFQ, based on the idea that everyday failures are caused by impairment linked to perception, memory, and behavior, was created by Broadbent et al.; answers about 25 items for everyday failures such as Do you forget where you put something like a newspaper or a book?, Do you fail to notice signposts on the road?, and Do you find yourself suddenly wondering whether you've used a word correctly? are given in five levels from Never (0 points) to Very often (4 points). An everyday failure is something that would normally be easy to do that fails to go well rather than something that cannot be done because it is too difficult. The CFQ has a high correlation for scores between tests even with retesting at various intervals, so it reflects individual characteristics rather than the state of the individual at that time.

However, the reaction regarding circumstances burdened by physical factors that are causes of mishaps in medical practice has not be examined as a characteristic of the vulnerability in cognitive function of individuals with high CFQ scores.

Thus, in this study cognitive characteristics of individuals with high CFQ scores in a time-critical situation, which is a physical factor that is a cause of mishaps in medical practice, were examined using a Stroop test to evaluate cognitive phenomenon.

The Stroop test is one of the most commonly used mental workload task, in which subjects see color words (e.g. blue) printed in either the color the word refer to or another color (e.g. red), and required to read the word or color of them. When the printed color is different from the color word, subjects usually take longer reaction time to name the printed color than when the word and color match, and reaction itself becomes more difficult. This cognitive phenomenon is known as the Stroop effect.

Individual differences in the reaction time for the Stroop test are assumed to be constant.

METHODS

1. Subjects
The CFQ was performed on 225 female university students (average age SD: 19.98 1.48 years) at Y University from whom consent was obtained after the aim of the research and methods were explained, and 30 individuals with the top CFQ total scores and 30 individuals with the bottom CFQ total scores were selected. Of these, Stroop test was performed on 29 individuals as subjects (14 individuals with high CFQ scores: CFQ H group and 15 individuals with low CFQ scores: CFQ L group) from whom additional consent was obtained regarding the experiment.

2. Apparatus
Equipments used in this experiment were:
EEG Monitoring System EE2110 (NEC San-ei, Tokyo, Japan) for monitoring and recording the timing of stimulus presentation and subjects' reactions, 12-bit A/D converter AXP-AD02 (ADTEK System Science, Yokohama, Japan) and Video camera recorder NV-S58 (Panasonic, Osaka, Japan). Stimuli were created on a personal computer ThinkPad 560X (IBM Japan, Tokyo, Japan) and presented on a 19 inch diagonal CRT display E67T (Eizo-Nanao, Ishikawa, Japan).

3. Stimuli and task condition

In this study, stimuli were created on the personal computer and presented on the CRT display. Each stimulus involved 56 colored words which were arranged 8 ~ 7. The size of a character was 0.7 ~ 0.8 cm, and the size of the display was 37 ~ 27 cm. The viewing distance for the subjects was set to 65 cm. Four types of words were used:  red, blue, yellow, and green [in hiragana]; the colors used were the same colors.

In this experiment, five types of task conditions were provided using these words and colors; 1) black characters only (control), 2) words and colors that did not correspond at all (rate of agreement of 0%), 3) words and colors that 50% corresponded (rate of agreement of 50%), 4) words and colors that completely corresponded (rate of agreement of 100%), and in the current experiment 5) failed trial in which the stimulus disappear in a fixed time to foster urgency for subjects. For the failed trial, the rate of agreement for words and colors was 50%, and the stimulus presentation was set to disappear in 16 sec. during word reading condition and in 20 sec. during color reading condition.

In addition, the sound of a second hand sounded in all attempts as a sound effect to create a time-critical situation. An alarm was set to sound in the following times in consideration of the performance speed for each task: for word reading, 15 and 25 sec. after the task started; for color reading, 20, 30, and 40 sec. after the task started; for the failed attempt at word reading, 7, 12, and 16 sec. after the task started; and for the failed attempt at color reading, 10, 15, and 20 sec. after the task started.

These stimuli were used in one set with three patterns of rate of agreement of 0%, 50%, or 100% with word or color reading conditions; tasks were performed in four sets of 12 trials after a 3 min. of pre-experimental rest period, instruction, and the control trial and completed in 3 min. of post-experimental rest period. There were four attempts for failed attempts, with one trial after the first set, two after the second set, and one after the third set. Instruction in word reading or color reading was done before each task. The interval between attempts was 5 sec. To eliminate the order effects of stimulus presentation, the word reading, color reading, and rate of agreement were randomized.

4. Tasks

In this study, the Stroop test was programmed into a computer and performed automatically. Subjects answered vocally in accordance with instructions to read a word (word reading) or read a color (color reading) that appeared on screen.

5. Records

During the experiment, the timing of stimulus presentation and subject's responses were monitored and recorded using an EEG monitoring system and personal computer, and items of note were recorded on a chart. Timing of stimulus presentation was recorded directly
from the computer output, and the subject's responses were recorded by a voice-operated switch developed by the authors. In addition, the subject's reaction during the experiment was recorded on videotape.

6. Procedures
Before the experiment, the subject's name, age, etc. were indicated on paper. Afterwards, the position of both eyeballs with respect to the display was adjusted to the appropriate position. Instructions were given to subjects that the experiment would proceed automatically by the computer. Once they were understood, experimental control was assigned to the computer. The required time for the experiment was about 30 min. After the experiment, subjects filled in a questionnaire.

7. Instruction
Before the experiment, subjects were instructed that they should read the stimuli displayed on the CRT display as quickly and accurately as possible along with the order of reading. They were also explained that, when approaching the standard time for the reaction, a warning tone would sound to notify them. Before each trial, word reading or color reading direction was given and they were also directed to read even faster after the failed trial.

8. Questionnaire
In order to examine the degree of urgency for subjects and the degree of effort for the task, subjects are required to answer the questionnaire after the experiment with a Visual Analog Scale (VAS) regarding six items—Did you try as hard as possible on the next task?, Did you feel you were constantly pressed for time?, Did you tire of the task mid-way?, Did you notice the sound effects?, Were you nervous during the experiment? and Were you able to concentrate on the experiment? In addition, the impressions of the experiment were listed in free-response format.

9. Test hypothesis
When seen from the perspective of the CFQ H group's (1) more frequent needle stick accidents, (2) being more susceptible to inappropriate information from the outside world, and (3) more frequent mistakes in recognition or confirmation for accidents, the CFQ H group was assumed to have a slowed reaction time and make more errors as well in Stroop test in a time-critical situation than the CFQ L group.

10. Handling of errors
During the experiment, the experimenter recorded errors in a separate room closed off with a curtain and they were reconfirmed with the recorded video after the experiment. Error classification referred to Shimada's error classification pattern (Table 1).

Table 1. Error classification

<table>
<thead>
<tr>
<th>1.</th>
<th>When orally responding with other color characters without making a correction.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>When orally responding with other color characters and making a correction.</td>
</tr>
<tr>
<td>3.</td>
<td>When skipping color characters and reading the next color characters or reading color characters other than those written.</td>
</tr>
<tr>
<td>4.</td>
<td>When saying the correct answer and then going back and reading the same item again.</td>
</tr>
<tr>
<td>5.</td>
<td>Being stuck for words before making the correct response (um, um, 　and the like).</td>
</tr>
<tr>
<td>6.</td>
<td>When reading characters during a color reading task or when naming a color during a character reading task.</td>
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</tbody>
</table>
11. Data Reduction and Analysis
During the experiment, the timing of stimulus presentation and subject's responses were simultaneously A/D converted with a sampling frequency of 100Hz and stored on the personal computer for off-line analysis. For the detection and analysis of reaction timing, the software developed by Ohsaga et al. were used. In addition, errors were classified based on the classification listed in Table 1 and analysis performed. Statistical Package for the Social Science (SPSS) for Power Macintosh Ver. 6.1 was used for statistical analysis.

RESULTS

1. Reaction time
The reaction time was determined for each condition (CFQ, task conditions, and rate of agreement) and three-way repeated ANOVA...
CFQ (L group, H group) as between-subjects effect, task conditions (word reading, color reading) and rate of agreement (0%, 50%, 100%) as within-subject effect was conducted. The significant main effect of task conditions \((F(1,26)=179.68, p<.001; \text{Fig.1})\) and of the rate of agreement \((F(2,52)=199.39, p<.001, \text{Greenhouse-Geisser} \ (G-G) \delta=0.97; \text{Fig.2})\) was observed. As can be seen in Fig.1 and 2, reaction time for color reading was significantly slower compared to that for word reading and became significantly slower as the rate of agreement decreased. The main effect of the CFQ was not significant \((F(1,26)=0.41, \text{ns})\).

In addition, as showin in Fig.3 and 4, interactions were also significant between the rate of agreement and task conditions \((F(2,52)=98.17, p<.001, \text{G-G} =0.95; \text{Fig.3})\) and between the rate of agreement and CFQ \((F(2,52)=3.60, p<.05, \text{G-G} =0.97; \text{Fig.4})\). Although the reaction time in the color reading was related to the rate of agreement, the reaction time in the word reading was almost the same in each rate of agreement. In addition, when comparing the CFQ H group and CFQ L group, reaction times were always shorter in CFQ L group than in CFQ H group. Interaction between the task conditions and CFQ was not significant \((F(1, 26)=1.60, \text{ns})\).

2. Number of errors

The number of errors was determined for each condition (CFQ, task conditions, and rate of agreement) based on the classification indicated in Table 1. The same three-way repeated ANOVA on the number of the errors was run, that also demonstrated the significant main effect of task conditions \((F(1, 26)=43.28, p<.001; \text{Fig.5})\) and of the rate of agreement \((F(2,52)=35.87, p<.001, \text{G-G} =0.74; \text{Fig.6})\). During color reading, the number of errors was significantly high compared to that during word reading and became significantly higher as the rate of agreement decreased. Although, as is shown in Fig.7, the CFQ H group tended to make more errors compared to the L group, the main effect of CFQ on the number of the errors was not statistically significant \((F(1,26)=3.74, p=.064)\).

As illustrated in Fig.8, significant interaction between the rate of agreement and task...
conditions was observed \((F(2,52)=38.09, p<.001, G-G = 0.78)\). The number of errors increased as the rate of agreement decreased for color reading, while it was almost the same in each rate of agreement for word reading. And, as shown in Fig. 9, interaction between the rate of agreement and the CFQ was also significant \((F(2,52)=4.09, p<.05, G-G = 0.74)\).

The number of errors increased more steeply for the CFQ H group as the rate of agreement for words and colors decreased compared to the CFQ L group.

The same three-way repeated ANOVA was conducted on each item in Table 1 for errors. In uncorrected errors, the main effect of the CFQ \((F(1,26)=5.60, p<.05)\) was statistically significant. The CFQ H group tended to proceed with tasks without noticing errors compared to the L group.

3. Questionnaire

The one-way ANOVA \(F(1,28)=4.88, p<.05\) on each item of the questionnaire were conducted. As shown in Fig.10, the CFQ H group felt that they were constantly pressed for time compared to the L group \((F(1,28)=3.43, p=.075; \text{item } \text{Urgency})\). In addition, with regard to whether subjects noticed the sounds that they heard coming from the display, the CFQ H group tended to notice the sounds compared to the L group \((F(1,28)=2.92, p=.099; \text{item } \text{Sound effects})\).

In contrast, with regard to whether subjects tired out mid-way throughout the experiment as a whole, the CFQ H group tended to tire mid-way compared to the L group \((F(1,28)=2.92, p=.099; \text{item } \text{Tired feeling})\).


DISCUSSION

1. Reaction time

In the present study, reaction time for color reading was significantly slower compared to that for word reading. This result is supported by the finding that the reaction time for the naming of colors is slower than that for reading words\textsuperscript{[16]}, suggested by William James as a principle of psychology. In addition, significant interaction between the rate of agreement and task conditions was observed. This fact coincides with the finding that the time for the naming of colors quickens when the color and word match and the reaction time slows when the color and word do not match\textsuperscript{[16]} according to Shimada. Thus, previous results are supported in the current study and presentation on a CRT display is valid.

Regarding the association between a Stroop test and the CFQ, although the main effect of the CFQ was not noted, significant interaction between the rate of agreement and the CFQ was observed. Thus, the CFQ H group is more susceptible to the effects of the task load and their reaction slows as the burden increases compared to the L group.

2. Number of errors

In this study, significant interaction between the rate of agreement and the CFQ on the number of errors was demonstrated, so the number of errors can be construed to increase as the task load increases for the CFQ H group compared to the L group. In addition, a tendency for the CFQ H group to proceed with tasks without noticing errors compared to the L group was noted. This is a change in behavior characteristics appearing as the task load increases for the CFQ H group compared to the L group. That is, the fact that errors are readily made as the mental workload increases and, that errors are not readily noticed was suggested.

Fig. 10
Comparison of the urgency for subjects and effort on a task in CFQ Low group and in CFQ High group
3. Questionnaire

In a questionnaire to examine the urgency for subjects and the degree of effort on a task, the CFQ H group showed significantly greater feeling that the time was coming to an end and a tendency that the sound effects were uneasier than L group. In addition, answers with the content "pressed" were noted for the CFQ H group as an impression when they did not finish within the time allotted. In addition, answers for the CFQ H group that they "became confused mid-way as to whether what she answered was correct or not" were noted as an impression of the test as a whole. Thus, the CFQ H group is more susceptible to inappropriate information from the outside world and psychological confusion tends to readily occur when they run into a time-critical situation.

CONCLUSION

In this study, the behavior characteristics of individuals with high CFQ scores in a Stroop test were examined. As a result of selecting 29 individuals with high and low CFQ scores from 225 female college students at Yamagata University and performing a Stroop test, the following findings became apparent.

1) With regard to reaction time for a Stroop test, the reaction time slowed as the rate of agreement decreased for the CFQ H group compared to the CFQ L group.

2) With regard to the number of errors for a Stroop test, the number of errors increased as the rate of agreement decreased for the CFQ H group compared to the CFQ L group.

3) When the psychological state of the CFQ H group and the CFQ L group during task performance for a Stroop test were compared, the CFQ H group had a greater sense of being pressed for time compared to the CFQ L group.

These results coincide with our working hypothesis. When individuals with high CFQ scores run into a time-critical situation, which is a physical factor, the fact that task reaction time will slow and that errors will increase was suggested.

REFERENCES


