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STROOP TEST - A REFERENCE STIMULUS FOR PSYCHOPHYSIOLOGICAL MEASUREMENTS?

G. Geršak, J. Ogorevc, and J. Drnovšek

University of Ljubljana, Faculty of Electrical Engineering, Ljubljana, Slovenia, gregor.gersak@fe.uni-lj.si

Abstract: Numerous experiments dealing with measuring of changes in human physiology due to mental stress are reported. In these researches, a stimulus is commonly employed to mentally, emotionally or cognitively affect the human subject and hers/his perception, resulting in changes in physiology. When evaluating such experiments from the metrology perspective, there is a clear lack of consistence and knowledge in assessing such psychological stimuli.

In this paper we are presenting an attempt to evaluate a commonly used colour word conflict test - the Stroop colour test, in several versions. The physiological results indicate that different versions of the Stroop test induce different levels of psychophysiological answer.

Keywords: psychophysiology, Stroop test, colour word conflict test, reference stimuli.

1. INTRODUCTION

Psychophysiological measurements are measurements of the human physiology affected by psychological state of the subject. Psychological state of the subject changes due to various external (physical, chemical) and internal factors (emotional, cognitive, mental). The effect of these factors on human physiology was researched and reported in a number of papers. Published studies have reported effect of mental stress on changes in various physiological parameters, e.g. heart rate, skin conductance, skin temperature, blood pressure, respiration, muscle contractions, etc. Studies used different psychological stimuli, e.g. stress during colour-word tests, mathematical tests, mental strain, etc [1, 2, 3, 4]. It was shown that mental stress induced in the laboratory can produce a significant sympathetic response. Increase in blood pressure and heart rate were found to occur during mental stress tasks. Other reported effects were changes in skin conductance and skin temperature [5, 6, 7, 8].

Stroop colour word conflict test (SCWT), described in 1935 is one of the most studied and reliable psychometric tests [9]. It is based on psychological interference occurring when processes of reading colour words and naming ink colours interfere. In general, in recent publications Stroop test is popular because it requires a briefer period of cognitive load than other mental tasks, such as digit sorting [9].

This paper describes a comparison of different types of Stroop test in order to maximise the psychological effect on the subject

1.1 The classic Stroop test

Originally SCWT was composed of three experimental parts; a) the effect of interfering colour stimuli upon reading names of colours (Reading colour words), b) the effect of interfering word stimuli upon naming colours serially (Naming ink colours) and c) the effects of practice upon interference. Within the Reading colour words experiment, five different colour names were used for the subjects to read aloud. The experimental group was reading incongruent text and colours, e.g. the word “BLUE” written in green ink, and control group was reading the same text, written in black ink. The reading was timed and the result showed that there is no difference between the groups. In the second experiment - naming ink colours, the subjects were reporting the fill-colour of geometrical shapes (of five different colours). It was discovered that subject needed 75 % more time for incongruent as compared to the congruent words. In the third experiment, the effects of practice upon interference were studied and decrease in interference with number of rehearsal was reported.

1.2 Adaptations of the original SCWT

The original Stroop test was intended to investigate interference of text and colour recognition. Recently, while being widely used, the Stroop test is turning more and more into a stimulus, capable of affecting the person’s mental state and thus the person’s autonomous nervous system, resulting in changes of certain physiological parameters. The level of stimulation was found to be changed by means of shortening and lengthening the trial presentation time [10].

Recent studies are using different versions of the original SCWT test. Adaptations of the original Stroop test were described, using different number of words and colours [11], different modalities (voice, keyboard), different objects (words, pictures, videos), different orientation (e.g. picture of left arrow and the writing RIGHT). New variations of Stroop test were described, such as name-face Stroop task [12], emotional Stroop task [13], age-related suppression of word information [14], emotional counting Stroop task (colour naming interfered with by bottom-up processes

triggered by the emotional content of words whose colour must be named [15, 16].

Within our study we designed a complex SCWT. Complex SCWT protocol was the following: the subjects completed a 3 minute trial with successive series of three colour words (RED, BLUE, GREEN) written in incongruent colours (red, green, blue, and black, e.g. word RED written in blue ink) appearing in random order on computer display. The subjects had to identify the ink colour of the text and press the appropriate key denoting the colour of the text whenever the text was chromatic and to press the key denoting the meaning of the text whenever the text was achromatic (black ink). The subjects were instructed to perform the test at their maximal speed.

2. EXPERIMENT

The objective of this research was to find an adaptation of original Stroop test, which would exhibit the largest psychological impact of the subject. To find the version of Stroop test maximising the mental workload of the subject, three versions of Stroop test were evaluated. A classical paper-printed version Stroop test (xSCWT), a computer-aided classic Stroop test (cSCWT) and a complex Stroop test (SCWT) (figure 1).

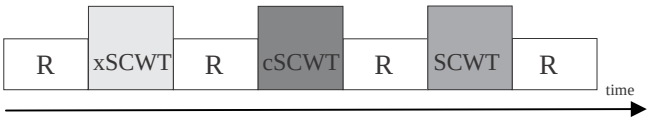

Figure 1. Measuring protocol – rest period for base line determination (R) is followed by three versions of the Stroop test (classical paper-printed version Stroop test (xSCWT), a computer-aided test (cSCWT) and a complex test (SCWT).

Classic SCWT was composed of three tasks – reading aloud the names of colours written in black ink (text recognition), naming aloud the colours of words, e.g. the word XYZ printed in three different colours (colour recognition) and naming aloud the colour of the text when the text appeared in a different ink than name of the colour (interference of colour and text recognition) (table 1).

Table 1. Description of used versions of Stroop test. Colour names (text) were written in Slovenian language.

version of Stroop test	text (names of colours)	ink colour
xSCWT - classic Stroop test		
part 1	RED, GREEN, BLUE	black
part 2	XYZ	red, green, blue
part 3	RED, GREEN, BLUE	red, green, blue
cSCWT- computer-aided classic Stroop test		
part 1	RED, GREEN, BLUE	black
part 2	XYZ	red, green, blue
part 3	RED, GREEN, BLUE	red, green, blue
xSCWT - complex Stroop test		
	RED, GREEN, BLUE	red, green, blue, black

Computerised classic SCWT was performed in the same manner, but using the computer display and answering by computer keyboard. The last test was the complex SCWT. Details of the tests are written in Table 1.

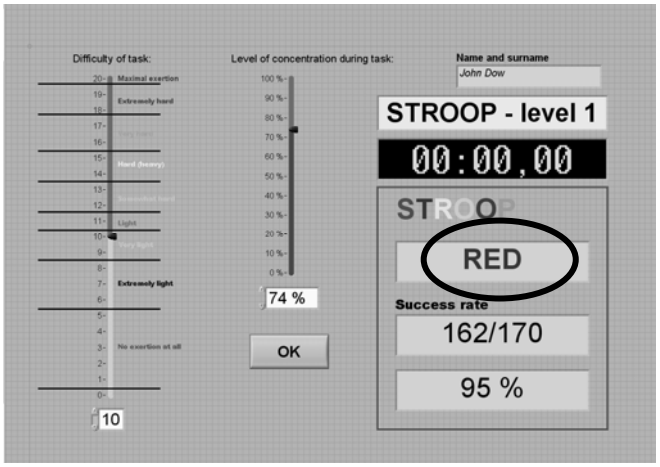

Figure 2. Front panel of the virtual instrument with text of different colour presented randomly (encircled). Below the current success rate is shown. Two sliders on the left are used for user self-evaluation of the difficulty of the task and user's level of concentration during it.

2.1 Psychophysiological measurements

The effect of the tests was measured by means of psychophysiological measurements, i.e. measurements of blood pressure and heart rate, skin conductance and skin temperature (Figure 3). Blood pressure (BP) was measured non-invasively using a continuous beat-to-beat blood pressure monitor (CNAP Monitor 500 by CNSystems Medizintechnik, Austria). Skin conductance was recorded from bipolar leads on the distal phalanges of the first and second finger of the left hand by means of Biopac GSR100C and Biopac MPI150 acquiring system (by Biopac, USA). Skin temperature was measurement on finger tip by means of a fast thermistor (figure 3). The right hand was free for using the computer keyboard and computer mouse, thus minimising moving artefacts in acquired signals.

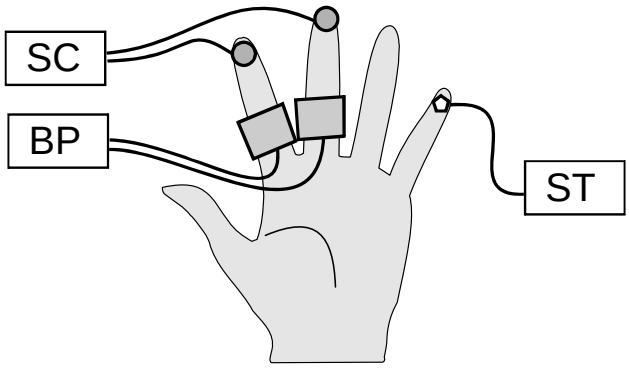

Figure 3. Position of sensors for physiological measurements (SC – skin conductance measuring device, BP – double cuff non-invasive continuous blood pressure device, ST – skin thermometer).

All the psychophysiological parameters were acquired with sampling frequency of 1 kHz during the test and analysed afterwards by means of Acqknowledge software package ((by Biopac, USA).

3. RESULTS

Changes in psychophysiological measurements were analysed and evaluated (figure 4). Additionally, final number of Stroop test answers, the percentage of correct answers, and average time of answering were recorded and analysed.. After the completed test, the subjects evaluated the level of their concentration during the test. To estimate the level of concentration while performing the test, a 0 to 100 % visual analogue scale was used.

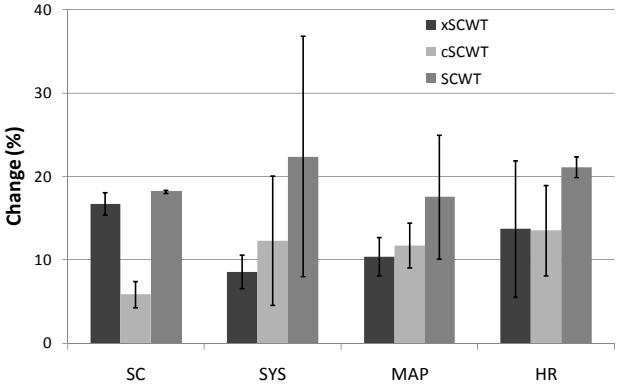

Figure 4. Physiological parameters (SC – skin conductance, SYS – systolic blood pressure, MAP – mean arterial pressure, HR – heart rate) were monitored while the subject performed seven levels of three types of Stroop test (xSCWT – classic Stroop colour-word test, cSCWT – computer-aided classic Stroop test, SCWT – complex Stroop test). The bars represent the relative amount of change of physiological parameters. The error bars represent ± one standard deviation of the measurements (n = 12).

4. CONCLUSION

Stroop word colour conflict test is psychometric test used as a stimulus to affect the level of psychological stress on subject. In this paper three different versions of classic Stroop test were investigated in order to find the one with maximal psychophysiological effect.

The results showed that complex SCWT provided maximal mental workload of the subject, not only due to interference of colour and text recognition, in case of chromatic stimuli, but also due to the additional decision process involved. Namely, according to stimulus chromaticity or achromaticity the participant first needed to derive a decision about what characteristic of the word had to be processed. As such it is conveniently suitable to be used as a stimulus triggering changes in psychophysiology of a man.

Future work includes timing the responses; not only measuring the temporal response of typing on the keyboard, but also timing of audio responses with voice recognition within the classical Stroop test while the subject is reading aloud.

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