INVESTIGATING THE STROOP EFFECT IN CHILDREN WITH PSYCHIATRIC DISORDERS

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ABSTRACT

The Stroop test evaluates the capacity to classify and discriminate between different visual stimuli (words and colors). Imagistic MRI studies have shown that during the Stroop test different brain areas are activated, such as: anterior cingulate gyrus, parietal lobe, but also the dorso-lateral prefrontal cortex. All these areas are involved in various neurodevelopmental disorders, such as ADHD, autism spectrum disorder, oppositional-defiant disorder and mood disorders. This pattern suggests a possible use for this test in further studies of ADHD, depression, obsessive - compulsive disorder. The main purpose of this study was to evaluate the Stroop test as a possible screening method to differentiate between non-neurotypical and neurotypical subjects. Thirty nine subjects were included in this experiment - 22 subjects with psychiatric disorders (9 females) admitted at the Child and Adolescent Psychiatric Clinic of "Prof. Dr. Alexandru Obregia" Hospital, Bucharest; and 17 subjects without psychiatric disorders (7 females) chosen from Pediatric Surgery in "Grigore Alexandrescu" hospital, Bucharest. The Stroop test was created in Open Sesame Python using an array of six colors: yellow, orange, red, purple, blue, green. Two types of cases were presented: a color-word congruent and a color-word incongruent scenario; the subjects decided if the presented scenario is concordant or discordant without speaking. The evaluated parameters were the answer latency and the number of correct answers. The data was analysed using Microsoft Office Excel and IBM SPSS 16.0. We found a compelling difference between answer latencies of different colors ($\chi^2(5,39)=45.293, p<0.001$) with higher latency for yellow and orange in comparison to other colors. The perceived concordant latency was found to be lower than the perceived discordant latency (Z= -2.442, n1=n2=39, p=0.015) and the difference persisted for the predefined concordant and discordant latencies (Z= -3.363, n1=n2=39, p=0.001). Findings from this study included a slight increase in latencies of non-neurotypical subjects compared to neurotypical ones, with a low statistical significance and differences between sexes, males having a higher answer latency. Moreover, we noticed that there are consistent differences between the latencies for specific colors, with yellow and orange inducing slower response times. Overall, we consider that the field needs further investigation, and that we need to conduct more studies on specific pathologies. The small number of subjects for each pathology, as well as the heterogeneity of the ages of the subjects are obvious limitations of the present study, however, we consider that our results support the extended research in this domain. The main advantage of a computer-assisted screening test is that it can be easily employed in a home setting, which makes this Stroop test a potential candidate for such an attempt, provided that our future studies will confirm its specificity and sensitivity. This study is the first of its kind conducted in Romania. We propose that the Stroop test could be used as an auxiliary method in the diagnostic of psychiatric disorders in child and adolescent psychiatry.

Keywords: Stroop test, child, psychiatry.

INTRODUCTION

The Stroop Colour-Word Test „assesses the ability to change the strategy by suppressing the habitual response and offering a new response when dealing with new stimuli”[1-3].

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Over the years, there were attempts to create tests similar to the Stroop test, but those did not get the same results. The uniqueness of the Stroop test lies in the fact that the word-naming and the colour-naming processes require the same neuropsychological functions. In addition, the response speed for these two activities (word reading and colour recognition) means that the word reading response occupies the same neuropsychological pathways that are needed, at the same time, to process the colour recognition response.

Before Stroop’s study, many papers trying to explain interference and its consequences were published and some of the most relevant are mentioned here.

Cattel (1886) concluded that the time required to read the words is much lower than the time required to name colours and he attributed the difference to the unequal practice of these two activities [4].

Woodworth and Wells (1911) stated that “the real mechanism may very well be the mutual interference of the five names, all of which, from immediately preceding use, are ‘on the tip of the tongue’, all are equally ready and likely to get in one another’s way” [5].

Brown (1915) concluded that “the association process in naming simple objects like colours is radically different from the association process in reading printed words” [6] and Garrett and Lemmon (1924) summarized their findings by saying that “Another factor present in interference is very probably the present strength of the association between colours and their names, already determined by past use” [7].

Peterson, Lanier and Walker (1925) attributed the difference to the fact that “one particular response habit has become associated with each word while in the case of colours themselves a variety of response tendencies have developed”[8].

Initially, the studies were based on the inhibitory effects of attention. It was considered that in order to solve the test as well as possible, the subject should ignore the name of the colour when he has to state the colour in which it is printed. At the time, studies were focusing more on elucidating the origins of this attentional selection rather than on discovering an inhibitory mechanism, but there were papers which backed up the existence of such a mechanism. An exemple, in this regard, is Greewald’s work, published in 1972.

Some neuropsychological studies have shown that the interference in the Stroop test occurs as a result of the interference between verbal and nonverbal processes in response time [12]. This is better explained by the theory of automaticity in terms of cognitive processes. Thus, we have two major categories of cognitive processes:

a) automatic processes. These are processes that are not controlled by the subject, they do not consume resources, so they do not decrease attention or processing capacity and are often stereotyped, information processing taking place in parallel;

b) voluntary processes. Unlike automatic processes, voluntary processes are controlled by the subject, they require a certain amount of resources depending on their complexity, so they consume attentional capacity and require effort from the subject, information processing taking place in sequence. They have a greater ability to adapt when facing new situations and they can be enhanced with practice [10].

Applying this theory to the Stroop test, we see that we are dealing with two distinct processes: on the one hand, word-reading response is automatic, while on the other hand, colour-naming is a voluntary process.
When solving the test, the subject performs two actions sequentially: word-reading followed by colour-naming; or he/she inhibits the automatic answer of reading the words by voluntary control. There are people who may suppress reading response and focus on naming the colours; others are able to suppress the verbalization of the name; and there are people who have a very high level of interference and the two responses are very easy confounded [11].

Based on these data, Kahneman and Treisman (1984) argued that "a weak reader interference levels will not look as big as an expert reader" [12].

Today, there are several theories that attempt to explain the way in which the interference that occurs during Stroop test execution and the variations in terms of results was solved. These theories are based on selective attention mechanisms and working memory, the ability to inhibit automatic responses (activities performed by the frontal lobe) and the concept of cognitive flexibility. All these processes thought to be involved were studied using imaging techniques.

The Stroop colour-word test assesses subjects’ ability to classify information received from the environment and selectively react to them and this makes the test useful in investigating a series of fundamental psychological processes.

There are three major processes involved in solving Stroop tasks:
Word reading
Colour recognition and naming
Interference resolution [16]

The Stroop test is used for:

- Detecting brain disorders affecting attention: selective attention, distributive attention or degree of distraction.
- Investigating psychiatric pathology and personality type;
- Diagnosing and understanding of organic brain dysfunction.

Stroop test scores can tip the balance towards a certain type of pathology and may indicate the location of an injury. Examples [13]:
- All scores are low - diffuse lesions of the left hemisphere;
- All results are within normal limits – decreases the probability of an extensive brain damage, but does not exclude the existence of isolated brain injury especially if it is located in the right hemisphere;
- Scores within normal limits in word-reading and low in colour-naming and in colour-word card - may suggest that there is either damage to the right hemisphere leading to inability to recognize and distinguish colors in the left hemisphere, so the patient can not assign a name to the color;
- Scores within normal limits in word-reading and colour-naming subtasks and low in the colour-word card - isolated lesions of the prefrontal cortex, especially the left one or bilateral lesions. It is sensitive to early forms of cerebral atrophy making it useful in early detection of dementia;
- Lower scores in word-reading, normal in colour-naming and increased in colour-word card - suggestive of the diagnosis of dyslexia. The patient being unable to read, does not experience any interference when the color and word are incongruent.

Other categories of patients where this test may be useful:
- Patients with schizophrenia - they obtain lower scores than normal subjects [18].
• Alzheimer patients – where one can observe a decrease in processing speed and a latency increase in the naming of color versus reading the words of neutral colour.
• Patients with eating disorders. Bulimic patients have a low level of inhibition of impulsive behaviors18, while anorexic patients have a higher latency time when they need to name the color of words related to food [19].
• Patients with psychiatric disorders - are generally easily distracted and find it difficult to complete the work they started. Emotional Stroop test has been used on patients with different pathologies also:
  • Patients with chronic pain - their results are not significantly different from those achieved in the control group20.
  • Patients with depressive spectrum disorders - their results show that the differences compared to the control group occur only in patients with severe depressive disorder [21].
  • Patients with alexithymia - results showed that patients with high levels of alexithymia are less susceptible to interference caused by emotional stimuli, they are affected by the emotional nature of the stimuli [22].
  • Patients with panic disorder - whom are much less prone to automatically process the information [23].

The development of medical imaging techniques made it possible to study brain activity during the Stroop test.

Over time there have been used:
- MRI (Magnetic Resonance Imaging)
- fMRI (functional Magnetic Resonance Imaging)
- PET (Positron Emission Tomography)

Cognitive processes involved in solving the Stroop test (response inhibition, interference resolution) are considered the prerogative of the frontal lobe. In 1974, Perret proposed the frontal lobe as the place where these processes are conducted after studying a group of patients with frontal lobe injuries. Because the execution of the test is so strongly linked to the function of the frontal lobe, the test turned into a very good method to study the development of executive processes being used in studying maturation [16]. In studies conducted on adults, although there is a rather large variability in terms of the areas observed as being active during the test, most investigators have found at least one of the following areas:
  - Anterior cingulate cortex;
  - Parietal lobe;
  - Lateral prefrontal cortex [16].

Positive and negative correlations between Stroop test results and various factors that may influence these results have been looked for over the years.

Among the factors that were investigated are demographic variables: age, sex and level of education.

In terms of age, most authors have concluded that scores decrease with age, but there is no consensus. The explanation for the decrease could be a lower control of the executive function. The level of education affects the number of mistakes made by the subject more than the time needed to complete the test.

The combination of old age and low education has the strongest effect on the scores, which supports the theory that education plays a protective role for cognitive functions. Most studies on the effect of the sex of the subject have shown that women obtain better results in colour subtask, but no significant differences in word and color-word subtask.

The first major study conducted on children was that of Lidon in 1932, which showed that the processing speed increases with age, result being confirmed three years later by Stroop.
An extensive study that included both children and adults and the elderly, age limits being 7-80 years old, was the one made by Comalli, Wapner and Werner in 1962. They had a number of 235 subjects whom they divided into 11 age groups. Seven year old children were the slowest, while teens in the age category 17-19 years showed similar results with adults.

Another study [24] conducted on children divided into 4 age groups: 6, 9, 12 and 16 compared not only the time required to fulfil the task, but also the number of mistakes, which decreases with age in all 3 subtasks, and the number of unsatisfactory replies which had the highest values in the 6 year old group and the lowest in the 16 year old group.

All these studies show that while in adults age has no major influence on outcomes in children this changes greatly. Cognitive maturity is achieved only in adulthood, so the scores change as age increases. The Stroop test can be used to assess children's normal functional development by comparison to other results obtained in the same age group.

However, the level of development may not correspond to biological age. In a study by Das in 1969 conducted on two groups of children aged between 10 and 15 years, including some diagnosed with mental retardation and some normal in terms of cognitive development, it was noted that the first were quicker to appoint the color in the color-word card, showing their low level of development. Das calculated the intelligence quotient (IQ) using RAVEN-standard matrix and observed that it correlates with the Stroop test results.

Other factors that were studied are [13]:

• Stress. Subjects solved the test against noisy background in two different situations: one in which it was necessary to pay attention to the information they receive and the other in which the noise was to be ignored. In the first case results showed an increase in the time required to fulfil the color-word subtask compared to the values obtained in a quiet environment. In the second situation, there has been a decrease in time, explained by the fact that both activities carried out by the subject required inhibition, thus increasing efficiency.

• Medications. They compared the effects of depressant drugs, most eligible for use being amobarbital, with the effects of stimulant drugs, the most used being amphetamine, and with placebo. The subjects took the test before and after taking the drug / placebo. Depressants have been shown to increase the degree of inference and stimulants to decrease it, the latter making it possible to focus on the task in progress and ignore distractions.

• Alcohol. Alcohol makes the colour naming process difficult and the effects depend on the dose ingested; the higher the dose, the more lasting the effects. Also, there is a great variability among subjects.

• Coffee does not change the results regardless of the dose.

• Drugs. LSD produces a decrease in all scores, while marijuana gives no significant changes.

\textbf{The purpose of the study}

This study was aimed at evaluating the possibility of using the Stroop test and the SCARED questionnaire – the child version – as screening methods for detecting the differences between neurotypical and non-neurotypical subjects.

\textbf{Goals:}

1. Evaluating the differences between the Stroop test results of a non-neurotypical group and a neurotypical group.
2. Evaluating the differences between the SCARED questionnaire scores for a group of non-neurotypical and one of neurotypical subjects.

3. Evaluating the correlation between the results obtained at the Stroop test and the scores obtained at the SCARED questionnaire.

MATERIAL AND METHOD

The study was conducted on 2 groups of subjects. One consisted of 22 patients diagnosed with psychiatric disorders (non-neurotypical) and a control group consisting of 17 subjects without psychiatric disorders (neurotypical). Non-neurotypical subjects were selected from the Child and Adolescent Psychiatric Clinic of "Prof. Dr. Alexandru Obregia" Hospital, while the control group was selected from the department of Pediatric Surgery in "Grigore Alexandrescu" Hospital in Bucharest, during July-August 2015.

Since the participants were all children, informed consent was obtained from their parents/legal guardians.

The charts of the patients from the two sections of the clinic were tracked throughout this period of time.

The evaluated epidemiological parameters were: age, sex, height, weight, the environment and level of education. There were also recorded: diagnosis, IQ, other tests and scales and also the on-going treatment.

Of all patients registered at the time, 43 subjects were identified as possible participants to the study, but after talking to them, the number dropped to 28. It was noted that despite age and education level (sometimes even for 4th graders), for 8 subjects the ability to read was at an inappropriate level for the study (they were either not able to read at all or they were able to read the letters only one at the time). The remaining 7 refused to participate in the study.

Out of the 28 records only 22 were used in the statistical processing. The remaining 6 contained errors created by the participants’ impulsive behaviour.

There were used: a computerized version of the Stroop colour-word test and the version for children of the SCARED questionnaire.

The Stroop test used in this study was created in Open Sesame. We considered a computerized version necessary to ensure more precise results. For this, the xpyriment back-end was used, a back-end specifically designed for conducting experiments that require precision when time is concerned.

This version differs from the original Stroop test by:
- The number of colours used. There were six colours used: yellow, orange, red, purple, blue, green
- The fact that it presents only two situations for the subject: colour-word congruent and colour-word incongruent scenario, without a neutral situation (the name of the colour written in black). In this type of situation, the subject must decide if the presented scenario is concordant or discordant, without having to pronounce the word or the colour written on the screen.
- The assessment of the results. Generally, the measured items are either the number of words read / the number of recognized colours in 45 seconds, or the time needed to read 100 words / to recognize 100 colour. In the present situation, the response latency was measured for each of the 60 test cases.

The test sequences were:
1. The selection of the age group (6-10 years old, 11-15 years old, 16-18 years old)
2. The selection of gender (M/F)
Investigating the STROOP effect in children with psychiatric disorders

3. The explanations of how to conduct the tests (“a series of words will follow”, “when the colour matches the word, press the button <a>, when the colour does not match the word, press the button <1>”). If the subject required further explanation to understand, these were offered by the investigator.

4. An experimental session: a series of six words matching the 6 colours so that the subject can get used to the colours used.

5. On-going explanations once again (eg: “the actual test starts here”).

6. The test itself was represented by a series of 60 cases of congruence and incongruence organized evenly by colours (each colour appeared 10 times).

The subjects were explained that they must complete the test as quickly as possible and with as few mistakes as they can. The test was performed by all the participants on the same electronic device.

Statistical analysis: the data was analysed using Microsoft Office Excel and IBM SPSS 16.0. In order to determine the appropriate statistical tests matching the group in question, the data distribution was checked using the Shapiro-Wilk test. Parametric tests were used for the case where the p - thus obtained was greater than 0.05. Otherwise, non-parametric measurements were used.

RESULTS

The control group comprised of a total of 17 subjects, 7 girls and 10 boys between 7 and 17 years old.

The group of patients included 22 subjects, 9 girls and 13 boys with ages between 8 and 17 years old.

In order to test the differences between the measured parameters, we used non-parametrical tests (Mann-Whitney signed ranks test, Wilcoxon test, Kruskal-Wallis test and Friedman test- a non-parametric version of repeated measures ANOVA), as well as the Spearman test for testing correlations.

There were no statistically significant differences between the two groups regarding the measured parameters (table I).

Table I. The value of the statistical significance of the differences between measured parameters.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control Group</th>
<th>Patients Group</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>latenta_concordanta</td>
<td>150.05</td>
<td>170.03</td>
<td>0.012</td>
</tr>
<tr>
<td>latenta_discordanta</td>
<td>200.03</td>
<td>230.01</td>
<td>0.023</td>
</tr>
<tr>
<td>latenta_perceputa_concordanta</td>
<td>180.00</td>
<td>200.01</td>
<td>0.018</td>
</tr>
<tr>
<td>latenta_perceputa_discordanta</td>
<td>220.02</td>
<td>240.01</td>
<td>0.010</td>
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</table>

Given that there were no differences between groups in terms of specific latencies, all latencies obtained for concordant situations were compared to those obtained for the discordant situations and
those for perceived concordant with those for perceived discordant. The perceived concordant latency is lower than the perceived discordant latency ($Z = -2.442, n_1 = n_2 = 39, p = 0.015$), and the difference is also maintained for the predefined concordant and discordant latencies ($Z = -3.363, n_1 = n_2 = 39, p = 0.001$) (fig 1-3).

There was a significant difference between latency values depending on colour ($\chi^2 (5, 39) = 45.293, p < 0.001$), with higher latencies for yellow and orange than for the rest of the colours. (Figure 4).

There were no significant differences between groups on the SCARED test scores, except for Score 2 (Table II.), where patients with psychiatric pathology obtained much higher scores than neurotypical children.

Also, the existence of a difference between the latency for correct answers the latency for wrong answers was verified and there was none ($Z = -0.53, n_1 = n_2 = 39, p = 0.596$).

Table II. Mann-Whitney test results in terms of SCARED score differences. (scor=score)

<table>
<thead>
<tr>
<th>Test Statistics $^b$</th>
<th>scor</th>
<th>scor</th>
<th>scor</th>
<th>scor</th>
<th>scor</th>
<th>scor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wilcoxon $Z$</td>
<td>-6.71</td>
<td>-6.71</td>
<td>-6.71</td>
<td>-6.71</td>
<td>-6.71</td>
<td>-6.71</td>
</tr>
<tr>
<td>Asymp. Sig. (2-tailed)</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Exact Sig. (2-tailed)</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

$^a$ Unadjusted for ties
$^b$ Grouping Variable: let

There were no gender differences in the SCARED questionnaire responses, but discordant, perceived concordant and perceived discordant
latencies as well as latencies for right and for wrong answers have varied significantly by gender, with higher values for boys than for girls. (Table III).

### Table III. Classification by SCARED questionnaire

<table>
<thead>
<tr>
<th>Test Statistics</th>
<th>DCCG</th>
<th>DCCG</th>
<th>DCCG</th>
<th>DCCG</th>
<th>DCCG</th>
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<th>DCCG</th>
<th>DCCG</th>
<th>DCCG</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (years)</strong></td>
<td>10.85</td>
<td>13.58</td>
<td>11.98</td>
<td>11.86</td>
<td>11.98</td>
<td>11.86</td>
<td>11.98</td>
<td>11.98</td>
<td>11.98</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td>284.85</td>
<td>284.85</td>
<td>284.85</td>
<td>284.85</td>
<td>284.85</td>
<td>284.85</td>
<td>284.85</td>
<td>284.85</td>
<td>284.85</td>
</tr>
</tbody>
</table>

In order to identify correlations, Spearman test was used. Significant correlations are highlighted in Table IV

### Table IV. Identify correlation by Spearman test.

DISCUSSIONS

The Stroop test and the child version of SCARED questionnaire can prove to be very useful screening tools in clinical practice since their benefits are that they are both cheap, simple and easy to apply.

In the present study, the Stroop test and the SCARED scale do not have a high specificity in the studied group. It was observed that: A gender difference in terms of results, with an increase in response latency in boys; A correlation between scores obtained on the Scared scale and response latencies in the Stroop test. This shows that the Stroop test can be successfully applied in an integrative context with other screening tools.

The limits of this study need to be discussed.

The size of the group. The small number of subjects and great heterogeneity in terms of pathologies and ages included. It is recommended to resume the study on a larger group of non-neurotypical subjects so that statistical significance can be established for the pathologies included in the study and the results obtained. Also, studies can be conducted on a single pathology, a good example being ADHD.

The version of the Stroop test used. The version used in this study is not the classical one and differs by the number of colours, the assessed dimensions and by how results were evaluated. Given the differences between the latencies for the colours yellow and orange and the rest of the colours, for a future study it is recommended a version that does not contain these two colours.

Also, given the level of education of children with psychiatric disorders in our country, it is advisable to use a version of the Stroop that also contains a neutral scenario (the name of the colour written in black ink) for a correct assessment of the ability to read thus avoiding an error in evaluating the results obtained in the situation of incongruity. An Ishihara test may also be associated to eliminate the possibility of colour perception disorder. This study is the first of its kind in medical works in Romania. It is a pilot study that allows the development of further studies taking into consideration the presented recommendations.
CONCLUSIONS

There was no statistically significant difference between latencies obtained by the non-neurotypical group and the ones obtained by the neurotypical group.

There was no statistically significant difference between the number of correct answers provided by the non-neurotypical group and the neurotypical subjects.

There was a tendency for latencies of non-neurotypical group latencies to increase compared to the neurotypical group.

It was noted that consistent perceived latency is lower than the discordant perceived latency on both groups of subjects.

It was noted that the perceived concordant latency is lower than the perceived discordant latency in both groups.

There was a statistically significant difference among latencies obtained for yellow and orange colours and latencies obtained for the remaining colours on both groups of subjects.

The only statistically significant difference between the two groups in terms of Scared scores was observed on scale 2 - Generalized Anxiety Disorder.

There were no significant differences between the various scores and latencies in terms of pathology.

There were no gender differences in the SCARED questionnaire responses.

There was a significant variation of discordant latency, perceived concordant latency, perceived discordant latency, and the latencies for right and wrong answers based on gender, with higher values for boys than for girls.

There were no differences for any of the parameters measured by subjects' age.

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