SELECTIVE ATTENTION OF CROATIAN RAILROAD ENGINEERS FROM 25 TO 59 YEARS OF AGE: EMPIRICAL FINDINGS AND IMPLICATIONS

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Abstract

The findings on selective attention (SA) aging decline, although depending on the specific SA test, have significant implications for the population of professional drivers, in particular given their role in traffic safety. For this reason, we found it vital to examine the effects of aging on SA in railroad engineers and its relation to different measures of SA interference. A study was conducted by using 2 forms of the Stroop test: the 1st - verbal uncoloured and the 2nd - verbal coloured paper-and-pencil form. Both forms consisted of two parts: with incongruent stimuli (measured SA and processing speed, i.e. PS) and with neutral stimuli (measured PS). The subjects were male drivers of the Croatian Railways, ages 25-59, non-evenly distributed into 4 age groups distinguished by specific functional characteristics of professional drivers. 50 subjects completed the 1st and 52 completed the 2nd form. The subjects’ task was to cross out as many of the target words in the context of distractors during 60 seconds (with distraction more intensive at incongruent stimuli). Descriptive statistics for both forms of the SA interference (SA time – PS time) indicates expected mean scores, with normal distributions. The interference variability across age groups was homogenous at the 1st Stroop form, but not at the 2nd one. The mean number of errors in the 1st Stroop form is as expected, very low with positive asymmetric distributions and homogenous variability, while in the 2nd one, errors are evident only for the 30-39 age group. For the 1st Stroop form, a significant difference in SA interference time was found between the 40-49 and 50-59 age groups, the latter showing a higher interference. For the 2nd Stroop form, no significant effects of age on SA interference were found. The effect of specific experience of railroad engineers with colours (red-green) is indicated by the results. The findings are discussed in relation to the theory of cognitive aging and empirical findings in the general population, with the implications on railroad engineers aging process.

Keywords: selective attention, aging process, railroad engineers

1. INTRODUCTION

Population ageing strongly affects the view on workforce and related expectations. Since in developed countries people are living longer and the number of births is decreasing, the workforce is growing slower and the earlier retirement is discouraged (while return to work is more encouraged than ever), so the questions of enabling workforce to work longer [1], as well as relating the job performance with age, becomes even more important. Reviews of the workers age and the work outcomes suggest that
there are numerous processes that should be examined in relation to job performance, such as cognitive ability, personality, work motivation, etc. [1].

This kind of issues are particularly important for the transportation sector because of demanding tasks and schedule-depending working hours [2]. Therefore, it is relevant to explore the age-related changes at transportation sector employees in order to ensure effective and safe job performance. Since decline in cognitive abilities is “most acknowledged psychological change with age” [3] - and it is especially true of attention and memory - this study aims to get better understanding of SA in railroad engineers’ population. The SA is a set of cognitive processes with related neural basis, which purpose is to select receiving certain stimuli from some excitatory situation, while ignoring other stimuli from the same situation [4]. This is a key aspect of attention, since without it any other cognitive process couldn’t function well. Mostly, SA is measured by Stroop test, which consists of incongruent and neutral component and has been proven as reliable and stable measure of inhibitory mechanisms efficiency in a large variety of studies [5] [7] [9].

Performance in all Stroop tasks have the same common rationale: to inhibit more dominant distractor response while producing less dominant target response (for example, to name the colour in which the word is printed, while ignoring the word meaning) [6]. Interference of more and less dominant response is produced by stimulus incongruence (colour vs meaning) and is of less intensity when inhibition processes are stronger, i.e. when SA is larger. Inhibition efficiency assessment is usually conducted by comparing the performance in incongruent Stroop test component with the neutral component performance (namimg the colour of the coloured patches) and is measured by Stroop effect: difference between response latencies and/or the number of errors in the incongruent component as compared to the neutral one [5].

The age effect on the SA has been tested for years and age-related performance decline has been generally confirmed [8] [9] [10] [11]. Moreover, the most of the studies compared two groups, younger (average age 25) and older (average age 65) adults, and showed that interference is larger in elderly, since older people were less able to control the activation of conflicting word information. There are various explanations of the cause of the Stroop effect age related increase, but the most accepted one is the general cognitive slowing and sensory loses with age, including the aging deterioration of colour perception [9]. Furthermore, fMRI research revealed that younger and older adults differ in the patterns of neural activity associated with Stroop performance, whereby the older ones show less extensive activity in the brain area known as dorsolateral prefrontal cortex [11].

Taking into account previously mentioned importance of the SA for all other cognitive functions, and thus the work performance, this study significance imposes by itself. Vision and attention are extremely important for the railroad engineers work performance [1] that have quite challenging work conditions and great responsibility for traffic safety. As far as we know the SA age-related changes, measured by the Stroop, effect haven’t been analysed in railroad engineers’ population up to now, especially in Croatia. Data on SA efficiency and its age-related changes in railroad engineers can help experts to maximize traffic safety for both drivers and passengers by programming possible preventive interventions.
2. AIM AND HYPOTHESIS

The aim of the study is to examine the SA ageing effects of Croatian railroad engineers from 25 to 59 years of age through four age categories distinguished by specific functional characteristics of professional drivers, in relation to the type of SA operationalization - whether it contains traffic relevant colours or not.

1. Hypothesis: SA, expressed by interference time measures of the two Stroop test forms, changes non-linearly throughout the four functionally determined age categories: it is mostly stable in the 20-29 year and 30-39 period, while gradually declining during the 40-49 age and 50-59 age category.

2. Hypothesis: age-related changes in the observed SA measures differ throughout the four observed age categories depending on whether they contain traffic relevant colours or not.

3. Hypothesis: age related changes in colour versions of the SA measures point to certain specificities of the Croatian railroad engineers in relation to the general population of that age, which can be related to the job specificities and partially influenced.

3. METHOD

3.1. Participants

The participants were 102 male railroad engineers from 26 to 58 years of age, employed by the Croatian Railways. Since the research was conducted in two parts (July and end of September, 2015) 50 participants (Mage1=40.9, SDage1=9.35) were included in the first and 52 (Mage2=41.3, SDage2=7.26) in the second part of the research. The participants were non-evenly distributed into 4 age groups (20-29, 30-39, 40-49 and 50-59 age group) distinguished by specific functional characteristics of professional drivers.

3.2. Materials

Two paper and pencil test forms of the SA have been included in related two parts of research, representing two different operationalizations of the Stroop test. Both of them consisted of incongruent and neutral stimuli components that were separately administered in immediate succession (whereby the neutral stimuli component usually presents a conventional perceptual speed test).

Incongruent stimuli component of the first SA operationalization is an incongruent form (so-called “incongruence condition”) of the Lexical version of the Stroop test [12]. The component consists of 232 words, with fifty per cent of them being the word “big” and the other fifty per cent being the word “small” (in Croatian, “veliko” and “maleno”, respectively). Furthermore, fifty percent of both words are randomly written in upper-case letters and the other fifty percent in lower-case letters. Their semantic content and

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1 Reaction time (RT) ergonomics literature suggests ten years intervals in aging process analysis, starting from the age of 20, because of significant RT increment during that intervals [14]
position varied randomly within the lines and pages of the test. The participants’ task was to cross out as many of the words “small” as possible within 60 seconds and without skipping words or lines, no matter the word “small” was written in lower or in upper-case letters.

Neutral stimuli component of the first SA operationalization is a neutral form of the Lexical version of the Stroop test. The component consists of 448 words with fifty percent of them being the word “big” and the other fifty percent of them being the word “small” (in Croatian, “veliko” and “maleno”, respectively). All the words are written in lower case letters, and their semantic content and position varied randomly within the lines and pages of the test. The participants’ task was to cross out as many of the words “small” as possible within 60 seconds, without skipping words or lines.

As the testing outcome, in both tests’ components (incongruent and neutral) two variables were registered: (1) “the time for crossing out one target word” and (2) the number of errors (crossed out words “big” or omitted target words), with “the time for crossing out one target word” being the main variable. The primary SA measure was expressed by difference between the two test components’ main variables: “the time for crossing out one target word” in the incongruent component and “the time for crossing out one target word” in the neutral component (i.e. \( \text{SA time} – \text{PS time} \)). The secondary SA measure was expressed by difference between the two test components’ number of errors.

Discriminability of primary SA measure is high, indicated by variability coefficients (CV) with an average of 41.7 per cent. Also, there were no effects of floor or ceiling and the distributions of the primary SA results were normal at all four observed age periods (\( KS_{11} = .175, p = .200; KS_{12} = .171, p = .200; KS_{13} = .134, p = .200; KS_{14} = .192, p = .200 \)). Objectivity is highly obeyed because research assistants were previously trained for testing procedure, and then conducted the measurement in mostly standard conditions. Content validity is high because the test is very similar (beside the content itself) to coloured and other versions of Stroop test that is a widely accepted measure of selective attention [10] [13]. Discriminability of secondary SA measure is low because errors in these tests occur very rarely (at least 94% of all participants made no errors in the tests) and therefore calculating CV had no real meaning. Very low variability of this SA measure precluded reliable computation of all other metric characteristics and that’s the reason for not including this measure in further SA analysis, but only as control variable.

In the second SA operationalization (applied in the second part of the research), incongruent stimuli component is an incongruent form (so-called “incongruence condition”) of the paper and pencil version of the Stroop test which is often named as the “block version” of the test [5]. The component consists of 232 words in lower case, fifty per cent of them being the word “red” and the other fifty per cent being the word “green” (in Croatian, “crveno” and “zeleno”, respectively). Furthermore, fifty percent of both types of the words are randomly printed in red, and fifty percent in green. Their semantic content and position again varied randomly within the lines and pages of the test. The participants’ task was to cross out as many of the words “green” as possible - without skipping words or lines - within 60 seconds, no matter they’re printed red or green.

\(^2\) Larger number of neutral condition stimuli was needed since more of them are usually crossed out then the incongruent ones

\(^3\) \(KS_z\) = Kolmogorov-Smirnov z-statistic
Neutral stimuli component of the second SA operationalization is a neutral form (so-called “reading condition”) of the “block version” of the Stroop test. The component consists of 448 words with fifty per cent of them being the word “red” and the other fifty per cent being the word “green” (in Croatian “crveno” and “zeleno”, respectively). All the words were printed black and in lower case letters. The semantic content and position of the words again varied randomly within the lines and pages of the test. The participant’s task was to cross out as many of the words “green” as possible within 60 seconds, without skipping words or lines.

Similarly as in the first SA operationalization, in both tests’ components (incongruent and neutral) of the second SA operationalization, the two variables were registered: (1) “the time for crossing out one target word” and (2) the number of errors (crossed out words “red” or omitted target words), with “the time for crossing out one target word” being the main variable. Again, the primary SA measure was expressed by difference between the two test components’ main variables: “the time for crossing out one target word” in the incongruent component and “the time for crossing out one target word” in the neutral component. The secondary SA measure was expressed by difference between the two test components’ number of errors.

Concerning the objectivity and content validity of the second SA operationalization, the same can be stated as in the first SA operationalization. On the other hand, discriminability of the primary measure of this SA operationalization is even higher (average of 119.68 per cent). Again, there were no effects of floor or ceiling and the distributions of the primary SA results for three observed age groups were normal ($K_{S_{22}} = .105, p = .200; K_{S_{23}} = .183, p = .135; K_{S_{24}} = .104, p = .200$), while normality statistics couldn’t be calculated for the first group since it contained only two participants. Discriminability of the secondary SA measure (error number) was again very low (more than 95% of all participants made no errors in the tests), which precluded reliable computation of all other metric characteristics. That was again the reason for treating errors number as control variable in SA analysis.

### 3.3. Procedure

The research was conducted with the participant’s consent and on the official premises of the Croatian Railways at the main railway station in Zagreb, during July and September of 2015. It was a part of a more comprehensive study which, besides the SA tests, included several other psychological measures and a set of anthropometric variables. Although the testing in small groups was originally planned (up to 10 participants), it has been conducted predominantly individually (before or after the participant’s work shift). After taking participant’s personal data, the research assistants firstly read the standardized test instructions and explained the task to the participants by using examples. When stated understanding the instructions and measurement readiness, the participants attended the first test component in the given time (60 s). The two test components – incongruent and neutral – were rotated across the participants (in order to avoid the threats of repeated measure design). Research assistants monitored completion time by using a stopwatch and registered possible disturbances and relevant factors in a

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4The insight in the measurement protocols revealed no systematic relation between the participant’s age and testing before/after the work shift, so we didn’t find it relevant for the research hypotheses to test possible impact of testing time on the results.
measurement protocol. After completing the first test component, the participant immediately attended the second one, by using the same procedure. After completing all other psychological tests, materials were collected and the researchers answered participants’ possible questions concerning the whole study. Testing conditions were not laboratory primarily due to the low, but variable background noise and occasional entrance to the testing area by a third party. However, the measurement protocols analysis revealed low and non-systematic appearance of measurement disturbances, with no relation to participant’s age (as the main observed independent variable of the research design).

4. RESULTS

Since errors number in speed test might be related to response time, in order to exclude possible effects on primary SA measure, we first analysed that variable at in-congruent component of both versions of Stroop test.

Table 1: Descriptive statistics and results of Kolmogorov-Smirnov normality test for the errors number

<table>
<thead>
<tr>
<th>Age groups</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>min-max</th>
<th>Z_{skew}</th>
<th>KS_{z}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement 1 (Stroop1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-29</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0-0</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>30-39</td>
<td>13</td>
<td>0.23</td>
<td>0.44</td>
<td>0-1</td>
<td>2.36</td>
<td>.470**</td>
</tr>
<tr>
<td>40-49</td>
<td>17</td>
<td>0.06</td>
<td>0.24</td>
<td>0-1</td>
<td>7.85</td>
<td>.538**</td>
</tr>
<tr>
<td>50-59</td>
<td>11</td>
<td>0.09</td>
<td>0.30</td>
<td>0-1</td>
<td>5.02</td>
<td>.528**</td>
</tr>
<tr>
<td>Measurement 2 (Stroop2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-29</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0-0</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>30-39</td>
<td>23</td>
<td>0.04</td>
<td>0.21</td>
<td>0-1</td>
<td>9.97</td>
<td>.539**</td>
</tr>
<tr>
<td>40-49</td>
<td>17</td>
<td>0</td>
<td>0</td>
<td>0-0</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>50-59</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0-0</td>
<td>/</td>
<td>/</td>
</tr>
</tbody>
</table>

**p<.01

As can be seen from the results, particularly those regarding the coloured (or block) version of the Stroop test, extremely small number of errors was detected. Namely, in the first (lexical) version of the Stroop test no errors were recorded for the youngest group of the railroad drivers, while the average number of errors for the rest of the age groups was almost zero. In the second (block) version, in the whole group of 52 participants only one of them (from the 30-39 age group) made one error. The distributions of errors number, in all age groups where errors were detected, were significantly positively asymmetric, as shown by skewness z-test and by Kolmogorov-Smirnov normality test. They mostly resemble the Poisson distribution by which errors are usually distributed.

These data suggest that possible speed-accuracy trade-off (strategy of certain number of participants to favour speediness against accuracy despite the instructions setting the priority to correct answers) is not probable. That suggestion was confirmed by calculating Spearman correlation between errors number and the time needed for crossing out one target word - which was nonsignificant for both Stroop test versions ($r_s=-0.141$, $p>.05$ and $r_s=-0.238$, $p>.05$, for lexical and coloured Stroop test respectively).
All these results show that, although the errors number might be interesting variable for interference measurement (since interference potentially causes errors by creating confusion in participant’s fast responses), its contribution to age-related SA changes analysis is of marginal value.

Table 2: Descriptive statistics and results of Kolmogorov-Smirnov normality test for the selective attention measure (SA time – PS time)

<table>
<thead>
<tr>
<th>Age groups</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>min-max</th>
<th>Z_{skew}</th>
<th>KS_{z}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement 1 (Stroop1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-29</td>
<td>9</td>
<td>0.2</td>
<td>0.05</td>
<td>0.3-0.28</td>
<td>-0.08</td>
<td>0.175</td>
</tr>
<tr>
<td>30-39</td>
<td>13</td>
<td>0.16</td>
<td>0.11</td>
<td>-0.03-0.32</td>
<td>-0.16</td>
<td>0.171</td>
</tr>
<tr>
<td>40-49</td>
<td>17</td>
<td>0.16</td>
<td>0.08</td>
<td>0.05-0.37</td>
<td>1.56</td>
<td>0.134</td>
</tr>
<tr>
<td>50-59</td>
<td>11</td>
<td>0.29</td>
<td>0.07</td>
<td>0.12-0.37</td>
<td>0.52</td>
<td>0.192</td>
</tr>
<tr>
<td>Measurement 2 (Stroop2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-29</td>
<td>2</td>
<td>-0.11</td>
<td>0.17</td>
<td>-0.24-0.01</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>30-39</td>
<td>23</td>
<td>0.06</td>
<td>0.07</td>
<td>-0.05-0.25</td>
<td>1.67</td>
<td>0.105</td>
</tr>
<tr>
<td>40-49</td>
<td>17</td>
<td>0.09</td>
<td>0.09</td>
<td>-0.02-0.28</td>
<td>1.24</td>
<td>0.183</td>
</tr>
<tr>
<td>50-59</td>
<td>10</td>
<td>0.12</td>
<td>0.17</td>
<td>-0.15-0.41</td>
<td>0.1</td>
<td>0.104</td>
</tr>
</tbody>
</table>

Average Stroop interference values in first measurement (block version) are as expected, highest for the oldest group of railroad engineers and the lowest value for the 30-39 and 40-49 age groups. To examine the results variability differences among four groups, variability coefficients are calculated. They indicate high variability for the first (lexical) and especially for the second (block) version of the Stroop test, as commented in the Method. Regarding the second measurement it should be emphasized that, in the youngest age group of railroad engineers, only two participants formed that age sample, therefore confining further analyses for that group. The mean values of second measurement point to continuous growth of the Stroop interference from the youngest to the oldest age group, but the significance of the change has to be tested. All distributions are normal and symmetric, as indicated by the Kolmogorov-Smirnov and \( Z_{skew} \) test, respectively, although they should be treated with caution because of small sample size.

In order to verify the significance of the previously mentioned means differences, ANOVA and related nonparametric tests were conducted for each measurement separately. The ANOVA prerequisite assumptions analysis showed that, although in both measurement sets the results were measured on ratio scale and were independent within a certain age group, all other assumptions were not unambiguously met. Namely, (1) age-related samples were not drawn probabilistically from the population, although the sample covered some 30% of the population, (2) sample sizes, related to various age groups, were not equal (see Table 2), and (3) Levene’s homogeneity of variances test was barely insignificant in the first (\( F=2.44, df_1=3, df_2=46, p=0.08 \)), but not in the second (\( F=3.51, df_1=3, df_2=48, p=0.02 \)) measurement.

In the first measurement the ANOVA results (\( F=2.72, df_1=3, df_2=46, p=0.055 \)) showed that the SA differences among four age groups were almost significant. In order
to include deviations from ANOVA assumptions in the analysis, Welch robust test and nonparametric Kruskal-Wallis test were conducted and both of them pointed to significant SA age-related changes.

Table 3. Robust ANOVA and nonparametric test results for age differences in the selective attention measure

<table>
<thead>
<tr>
<th>Age groups (Stroop 1)</th>
<th>Welch</th>
<th>$F/\chi^2$</th>
<th>$df_1$</th>
<th>$df_2$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.01</td>
<td>3</td>
<td>24.16</td>
<td>.05</td>
<td></td>
</tr>
<tr>
<td>Kruskal-Wallis</td>
<td>8.12</td>
<td>3</td>
<td>/</td>
<td>.044</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age groups (Stroop 2)</th>
<th>Welch</th>
<th>$F/\chi^2$</th>
<th>$df_1$</th>
<th>$df_2$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.11</td>
<td>3</td>
<td>4.48</td>
<td>.43</td>
<td></td>
</tr>
<tr>
<td>Kruskal-Wallis</td>
<td>4.60</td>
<td>3</td>
<td>/</td>
<td>.204</td>
<td></td>
</tr>
</tbody>
</table>

Further analyses indicated that the difference was significant between 40-49 and 50-59 age groups of the railroad engineers ($U_{\text{Mann-Whitney}} = 33, z = -2.85, p = .004$).

In the second measurement the ANOVA results ($F=2.93, df_1 = 3, df_2 = 48, p = 0.043$) showed that the SA differences among four age groups were significant, but heterogeneous variances and large differences in sample sizes (2 vs 23) strongly suggested robust and nonparametric tests. The results of these tests clearly reversed the test conclusion by showing that there were no significant SA age-related changes in the coloured version of the Stroop test.

Incongruence in ANOVA and related robust and nonparametric tests findings should be overcame with statistical scrutiny, which suggest obeying ANOVA prerequisite assumptions. In that sense, the findings of robust and nonparametric tests are the relevant ones.

On the other hand the incongruence might stem from the nature of SA variable, i.e. SA time – PS time. Namely, that variable, although theoretically well based, is saturated with great portion of error variance, since it is calculated as the difference between two highly correlated variables ($r_1 = 0.89, r_2 = 0.83$, for the first and second measurement, respectively).

The way to take into account the very nature of SA measure when analysing its age-related changes, would be analysis of covariance (ANCOVA), whereby SA time being dependent variable, age group being independent variable, and PS time being covariate. The ANCOVA results are almost the same as the ANOVA ones ($F_1 = 2.63, df_1 = 3, df_2 = 45, p = 0.062$ and $F_2 = 3.28, df_1 = 3, df_2 = 47, p = 0.029$, for the first and second measurement, respectively), but they are also subjected to almost the same prerequisite assumptions – which were not unambiguously met. More precisely, it has one additional prerequisite assumption – equal $\beta$ coefficients in covariate-dependent variable regression, for every level of independent variable – which is also not perfectly met: (1) in the first measurement $\beta_1 = 0.96, \beta_2 = 0.69, \beta_3 = 0.94, \beta_4 = 0.93$, (2) in the second measurement $\beta_2 = 0.85, \beta_3 = 0.82, \beta_4 = 0.77$ ($\beta$ could not be calculated in the first age group since it contained only 2 participants).
Therefore, the possible advantage of ANCOVA approach in relation to ANOVA approach and its robust and nonparametric variations, is questionable - so we favoured the findings of robust ANOVA and nonparametric tests.

Finally, in order to analyse the shape of barely significant SA age-related changes in the first measurement (lexical version of Stroop test), we compared linear regression and some non-linear regression models fit. The curve estimation analysis (with SA measure being dependent and age group being independent variable) revealed that SA age-related changes resembled quadratic ($R^2= 0.15$, $df_1=2$, $df_2=47$, $p=0.022$) much more than the linear ($R^2= 0.015$, $df_1=1$, $df_2=48$, $p=0.397$) function, which is obvious from the Figure 1.

![Figure 1. Age-related changes of selective attention magnitude in four observed age groups in the first measurement (lexical version of the Stroop test)](image)

The first measurement sample of Croatian railroad engineers’ selective attention obviously changed non-linearly with age: it declined non-significantly in the age range 20-29, stagnated in the age range 30-49, and then increased significantly during the last observed decade (from 40-49 to 50-59).
5. DISCUSSION

In order to examine non-linear SA ageing decline in Croatian railroad engineers from 25 to 59 years of age, two possible interference indicators (i.e. inverted SA measures) were initially planned to consider – error based, and latency based Stroop effect. The number of errors, although interesting and useful interference measure [5] [15] [16], in this research didn’t show the properties needed for error based Stroop effect calculation. Namely, in applied Stroop tests the errors were extremely rare and related low variability didn’t ensure minimal psychometric qualities for including the errors number in Stroop effect calculation. Similarly to some previous research of Stroop effect [16] where errors were also rare, we used the errors number only to check possible speed-accuracy trade off, and since we didn’t find it, the errors number were excluded from further analysis.

Latency based Stroop effect clearly showed non-linear SA age-related changes in lexical, but not in coloured (“blocked”) version of the Stroop test. Moreover, in coloured Stroop test version, the SA age-related changes were not even significant, although there was certain tendency of aging related deterioration. Based on previous findings [5] [9] [11] significant SA deterioration was expected in coloured Stroop test version, especially between youngest and the oldest age group, because interference effect differs the most between students and all older age groups (mostly over 60 years). Possible explanations for the insignificance will be noted in further results difference analysis of two applied Stroop test versions.

On the other side, in lexical Stroop test version, the SA age-related changes were faintly significant just because the oldest two groups (40-49 and 50-59 years) differed significantly. These results are not completely in line with previous findings, which show that younger adults are generally more successful in SA tasks than the older ones [8] [9] [11] [17]. Namely, although the lexical Stroop effect decline from 20-29 to 30-39 years group is not significant, the opposite insignificant trend (i.e. growth) is expected. Possible explanation of somewhat larger interference values at the youngest group might lie in methodological confinement: the youngest sample size was the smallest one in the 1st measurement and under greater influence of sampling bias. Furthermore, it is little bit surprising that we got significant age-related difference using the variable with considerable portion of error variance (difference between two correlated variables), especially between two the oldest groups - both younger than 60 - since the greatest cognitive deterioration happens after the age of 60 [18] [19] [20] [21]. We might speculate of some earlier SA deterioration process in the observed sample of railroad engineers (at least in Croatia), and that it might be the consequence of generally negative health trends by all professional drivers [23] [24] [25].

Considering whether the SA age related changes depend on the presence of traffic relevant colours in applied Stroop test clearly confirmed that interference size, and its age-related changes depended on the type of interference. Namely, in Croatian railroad

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There is no specific data on the size of SA deterioration after the age of 60, but previous research [5] [10] [22] suggest that significant cognitive deterioration can be registered only by comparing younger persons with the ones older than 60 or 65 years (although it depends mostly on Stroop test version) [5] [10]
engineers the Stroop effect age-related changes didn’t occur in coloured version, but did in lexical version of the Stroop test. These findings, at least partially, were in line with Brink and McDowd [10], who noted that differences in the colour-block version of the Stroop test performance depend on the type or complexity of the test. Moreover, MacLeod [7] pointed to the number and kind of processes Stroop task includes (for example, colour-naming of the incongruent colour word includes more processes than colour-reading and thus causing greater interference effect) [8].

Different performance and age-related changes of two applied Stroop tests in this particular research might stem from the properties of railroad engineers performance in coloured version Stroop test. Namely, green and red colours from the research are frequently used for traffic signalization so they are very important and very familiar to railroad engineers. Their frequent exposure to these colours could be seen as training or exercise, which usually decrease Stroop effect, i.e. interference, even in older people [2] [11]. Therefore, although the older groups have larger interference than the younger ones, they also have longer experience with the relevant colours (green, red), which mutually compensates and final outcome is higher probability for insignificant age-related coloured Stroop effect. Putting together that outcome with (1) very small sample size of the youngest group (and related unreliable mean score), (2) weak cognitive deterioration under the age of 60 and (3) SA measure with considerable portion of error variance, we easily come to an explanation of nonsignificant age-related changes of the coloured Stroop effect. One might also assign non-significant SA age-related differences to positively selected participants by means of regular health and psychological check-ups, where all railroad engineers with severely damaged relevant functions are sent to prequalification [26].

The finding on practice effects has important implication for the experts responsible for facilitating and improving railroad engineers work conditions. These experts should not only analyse health determinants, bad habits and other harmful life style factors relevant for cognitive motor system activated during SA performance, but also stimulate exercise and training in various types of SA tasks. The ability to maintain well a set of cognitive functions, which includes activation and inhibition of responses dependent upon stimuli discrimination, is very important for the railroad drivers, especially when taking into account the nature of their shift work. If they would be trained with some new skills and educated how to better use the skills they already have, some of their work difficulties could be kept to a minimum and their related abilities could maximize.

6. CONCLUSION

Lack of data on railroad engineers SA age-related changes led to this research that included not only more age groups, but also more SA operationalization than conventional studies of SA age-related differences. Non-coloured SA operationalization mostly confirmed the expected non-linear SA ageing deterioration, showing that at 20-49 years age range there were nonsignificant decrements, which were found to be significant after the age of 50. Nevertheless, coloured (red-green) SA operationalization indicated age-related SA decrement through whole 20-59 age period, but didn’t reach significance, probably because of low reliability of SA operationalization, low general aging deterioration under the age of 60, positive health-based railroad engineers
selection, and biased participants' sample size which is at least partially assumed to be exposed to specific red-green traffic differentiation experience. Such a kind of "everyday SA training", together with the similar SA exercise and certain amount of health and working conditions interventions aimed to preserve SA neurological base (mostly concerned with environmental factors, working shifts and lifestyle habits), presents an expert field for SA improvement. However, in order to reveal specific SA aging deterioration mechanisms in railroad engineers, more comprehensive studies are needed with probabilistic sample (that might include subgroup of health damaged and prequalified railroad engineers) and environmental factors measurement, but also including more reliable SA operationalization and the set of health and lifestyle variables.

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