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Dr Justine Dandy

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David

Brown

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**A Stroop Colour-Word Experiment**

David Brown

Edith Cowan University

Abstract

Investigations into the differential time to read words and to recognise objects and colours associated with the words, known generally now as Stroop Effect experiments have held the interest of the research community from the mid 1800s until the present. In 1935 J R Stroop published the now classic paper describing three experiments investigating the attention interference effect that now carries his name. This paper reports an experiment that is similar to Stroop's second experiment. Twenty six ECU students, mean age 31.3 years, range 17 to 70 years participated in the counter-balanced within subjects experiment. Some limitations have been noted in the experimental procedure however the results support the Stroop Effect hypothesis that it takes longer to accurately read the colours of a list of conflicting colour words than the colours of a list of nonsense words.

A Stroop Colour-Word Experiment

Investigations into the differential time to read words and to recognise objects and colours associated with the words, known generally now as Stroop Effect experiments have held the interest of the research community from the mid 1800s until the present. (MacLeod, 1991) found about 400 papers pursuing a fully satisfactory theoretical model to explain the effects and another 300 investigating practical applications. Because of the simple implementation and reliably significant results, experiments relating to the Stroop Effect has also been found useful for introducing students to the excitement and satisfaction of quantitative experimental research (Boynton & Smith, 2006), (Hadley, 1996), (ECU, 2013).

In 1886, Cattell, a graduate student of Wilhelm Wundt, reported that it took longer to name the colour of words than to read the words themselves and suggested the effect was due to interference between well practised word recognition and the more complex recognition and colour naming task. A number of other researchers subsequently reported differences in times for recognition and reading using a variety of objects and conflicts (MacLeod, 1991). (Stroop, 1935) reverted to the basic theme of colours and colour names and published the results of three experiments. Subsequently researchers have referred to the effect as the Stroop Effect (MacLeod, 1991).

As described in (MacLeod, 1991) Stroop's first experiment tested whether printing words for colours in conflicting coloured inks effected the time taken to read the printed words. Stroop reported that his first experiment showed no significant effect on reading the words. The second experiment tested whether the presence of words for colours effected the time taken to speak aloud the names of conflicting ink colours. This second experiment showed that it took significantly longer to recognise and speak ink colours used to print incongruent words. The third experiment tested if several days of practice affected the time taken to read incompatible words and ink colours. Stroop reported that practice increased the word reading times and decreased the colour recognition and speaking times however was not sufficient to eliminate the effect found in his second experiment. A post-test indicated the effect of practice was transient. It is the delay arising from conflicting stimuli noted in the second experiment that is the subject of this experiment.

In the many experiments that have been performed researchers have attempted to discover in what human activities similar effects occur and based on this to develop a fully satisfactory theoretical model explaining the effect. Varying characteristics of participants, gender, age, language and other abilities, see for example (Laeng, Låg, & Brennen, 2005), (Tse & Altarriba, 2012) and (Emily, Walter, & Kathy, 2013) . Also variations in experimental stimuli and the processes of delivering the stimuli (Melara & Algom, 2003) and (Zoccatelli, Beltramello, Alessandrini, Pizzini, & Tassinari, 2010) have probed many aspects of the effect (MacLeod, 1991). Catell's early theoretical proposal that reading of words through practice had become an automatic process whereas a voluntary effort was required to choose the name of an object or colour, an automatic/voluntary distinction was carried forward by Stroop. Recent studies have supplemented this proposal with a parallel processing model, see (MacLeod, 1991) and (Cohen, Dunbar, & McClelland, 1990), which suggests multiple pathways for recognition and response each operating at a speed depending on practice and interfering with each other.

 The present experiment is similar to Stroop's second experiment. It requires that particpants read two pages of colour printed words, one page contains conflicting colour words, expected to cause interference and delay in response, and the other, nonsense words expected to be ignored with little or no interference or delay. Based on already published results of similar experiments it was hypothesed that participants would take longer to accurately read the colours of a list of conflicting colour words than the colours of a list of nonsense words.

**Method**

**Participants**

Twenty six participants were recruited for this experiment from the tutorial groups associated with the 2013 Semester 1 Research Methods in Psychology 1 Unit at ECU. There were eight male and eighteen female participants with varying backgrounds although all were deemed to have good english language capability, all were able readers with optical assistance where necessary and all were able to recognise the colours used on the materials. The mean age of the participants was M 31.3 years, range 17 to 70 years (SD 15.08).

**Materials**

Each participant was provided with two A4 test sheets, both printed with words in four columns and twelve rows, both sheets containing words printed in red, green, blue and yellow ink. One of the sheets had the words RED, GREEN, BLUE and YELLOW, each word repeated but none in their own colour ink. The other sheet was a similar pattern but the words were not semantically recognisable words, so-called nonsense words.

A results form was provided for each participant which was filled out with the participants identification, their gender, age and two spaces to record the times taken for reading each of the test sheets. A stop-watch timer accurate to 1/100th of a second in a mobile phone or similar was used by each pair of participants for recording the times for reading the test sheets. An instruction sheet that detailed the test process was provided for each participant.

**Procedure**

The design of this experiment was counter-balanced within subjects. The independent variable in the experiment were the two tasks, reading the colour words sheet and reading the nonsense words sheet. The dependent variable was the time to perform each task. All participants performed both tasks and their time for reading each sheet was recorded.

This test was carried out in a well lit tutorial room. For the test the members of each tutorial class were self-selected into pairs and the pairs performed the testing simultaneously. After reading the instruction sheet the personal details of each participant were recorded on each participants record sheet. Each pair then decided who would begin as time-keeper and, ensuring that the test was counter-balanced, one participant read the nonsense sheet first and following this the other participant began with the colour word sheet. The participants alternated reading and time-keeping until all sheets were read and their times recorded. The reading by each participant was monitored by the time-keeper for accuracy and completeness. The participants self-corrected the occasional stumble that did occur but no allowances were made as the times recorded would not have been significantly effected.

**Results**

Table 1 shows the mean times for the 26 participants to read the nonsense and colour-word pages. A dependent one-tailed t test was calculated on the difference in these times. Alpha was set at 0.05. All the assumptions of normality were met except for N < 30. Using Excel the t test was calculated t (26) = 7.40, p < 0.0005 which exceeds the nominated probability threshold for significance.

Table 1

*Times to Read Nonsense and Colour-Word Sheets*

Nonsense Words Colour Words Difference

*M SD M SD M SD*

27.62 5.51 38.00 11.17 10.38 7.16

The raw results and analysis leading to these results are included as Attachment A.

**Discussion**

The results of this experiment are consistent with the results of many other published experiments and show that the Stroop Effect held true in aggregate for the participants in this experiment. When recognising and speaking the printed colours of the words on the test sheets the participants in this experiment experienced various levels of interference arising from the english language colour words, their times were longer and, in some cases, they stumbled before announcing the colour, relative to their smoother and faster performance when the words were not meaningful. The t test analysis of the results of this experiment indicates the results were significant to p = 0.0005, however the small N < 30 sample size mitigates against generalisation of these results.

Despite the very significant aggregate performance by the participants in this sample there are a number of limitations that have been noted in our experimental procedure and a possible anomaly in our results that changes in our procedures could improve future repetitions of this experiment.

There was some prior concern of lack of concentration on the task due to noise and other disturbances occurring as several tests proceeded simultaneously. Some distraction may have occurred, the precise effect on the experimental results is not defined and it is a possible confound in our results. There was no explicit procedure defined for handling stumbles or incorrect responses during the reading of the sheets. The time keeping in our procedure was not standardised and was implemented between pairs of participants so the real accuracy and repeatability of time measurements is not certain.

All participants had access to the test materials for 3 weeks prior to the date of the test. As noted previously the third experiment by Stroop investigated and showed that practice affected the performance of participants. Referring to the raw data of our experimental results in Attachment A it it is noted that three of the participants were recorded with minimal, but still just positive, differences in their recorded times. These participants were among the youngest in the sample, they read the nonsense words sheets near the fastest and for the colour words they were the fastest of any in the sample. In many recent investigations there has been concentration on performance of participants to individually presented stimuli (Melara & Algom, 2003) and also the performance of individuals with different colour perception and other characteristics (Laeng et al., 2005). It is the latter and the possibility of practice prior to the experiment that might bear further investigation to understand the very low attentive interference experienced by our three notable participants.

Despite the noted limitations, this experiment supports the experimenter's expectations and the hypothesis that it takes longer to accurately read the colours of a list of conflicting colour words than the colours of a list of nonsense words.

Attachment A



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