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Advanced Age Interference

In the Stroop Color-Word Task

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## Abstract

Reaction time differences between younger and older subjects in the Stroop Color-Word Task were investigated. Reaction time was recorded in milliseconds in an automated study using control, congruent, and incongruent trials. Younger subjects demonstrated faster reaction times across all conditions compared to their older counterparts. Reaction times slowed on an increasing age continuum. Findings support the position that age is a major factor in reaction time and increased interference in the battle between automaticity, selective attention, and interference. Additional study is suggested with regard to timing of peak performance, general health of subjects, and more flexible manipulation of experimental apparatus.

## Advanced Age Interference

## In the Stroop Color-Word Task

For more than 65 years, experimental psychologists have been concerned with studying the human brain: how it processes information (i.e., serial versus parallel distribution, and controlled versus automatic processing) (Cohen, Dunbar, & McClelland, 1990) and the role of attention and interference (St. James, Schneider, & Rodgers, 1994). One of the most famous and widely used measures of this has been the classic Stroop Color-Word Task, or more simply the Stroop effect.

To understand the importance of the findings, one must first examine the implications concerning the human brain. Scientists hypothesize that humans have the ability for parallel processing; i.e., the ability to process several thoughts simultaneously (parallel), rather than one at a time (serial) (St. James et al., 1994). Likewise, it is believed that a person can engage in both automatic and controlled processes. An automatic process is one that is typically fast, does not require attention, and is difficult to change; e.g., driving a car after several years of practice. Conversely, a controlled process is voluntary, requires mental attention, is relatively slow, and can be changed with a minimum of effort (Cohen et al., 1990), e.g., assembling a swing set with a detailed set of instructions.

The Stroop Color-Word Task assesses how these concepts work together. Parallel processing assumes that one can accomplish several tasks at once. For example, one might mentally process both a color and a word at the same time. Interesting, however, is the premise that a person will respond with one ahead of the other, i.e., either the color or the word will be processed faster (St. James et al., 1994).

Why should this be so? If a person knows both colors and words, why then would one be processed faster than the other? Perhaps the answer lies in both attention and interference.

Attention may best be described as a process whereby there is a heightened state of arousal toward a particular train of thought. Various researchers have suggested that humans have a finite amount of attention available for thought. The Stroop task is a clear illustration of this phenomenon, as subjects are able to selectively attend to some aspects of the environment, but unable to ignore others. For example, subjects are consistently able to attend to color naming, but must first overcome the interference offered by color words, particularly when they are incongruent, or disagree, with the ink color displayed (Cohen et al., 1990).

Interference occurs when a person attempts to remove attention from a train of thought – and replace it with another. By engaging in selective attention, or attempting to focus on a particular stimulus while ignoring another, the brain should then process only the item being attended. However, research conducted using the Stroop effect suggests that it is not always possible to select, and both stimuli may be processed at once (St. James et al., 1994).

Again, this is illustrated perfectly in the Stroop Color-Word Task as it relates to both color and words in the battle for automaticity. Reading is a task that is learned in the early years of life and is practiced daily throughout the lifetime. While colors are also learned in the early years, they are not as well practiced as the reading of words. Therefore, it is likely that reading is more automatic.

In the Stroop Color-Word Task, subjects are asked to quickly name the ink color of particular words and symbols, while ignoring the words or symbols themselves. This typically presents little problem when there is a control condition (such as “xxxx”s on the screen). It also presents little problem when the word on the screen is the same as the ink color (such as the

word “red” in red ink color). There is a problem, however, when interference is introduced into the test by showing a word on the screen that contradicts, or is incongruent with, ink color (e.g., the word “green” in red ink). In this instance, evidence suggests that people unintentionally process the word instead of the color, hence supporting the hypothesis that reading is more automatic than color naming. This further suggests that automaticity is difficult to “turn off” (St. James et al., 1994).

Stroop study findings have repeatedly shown that the amounts of automaticity and interference within individuals undergo a change during the lifespan. In a 1962 Clark University study administered to 235 subjects, ranging from 7 to 80 years old, interference was greatest in young children, decreased through young and middle adulthood, and then increased again in those 60 years of age and older. Subjects were shown three types of 9 ¼” x 9 ¼” cards, with 100 items on each card, and were asked to verbally respond to each item. The card types consisted of color words printed in black ink, colored rectangular patches, and incongruent color words, respectively. While the age-related findings were significant, the early test did not account for possible health-related decrements in the elderly. An additional confound occurred when young children slowed their reaction time through physical pointing at the stimulus, and the elderly group often used a form of “verbal pointing” by preceding their response with “that’s a ----” (Comalli, Wapner, & Werner, 1962).

A much later (1984) study screened subjects for cardiovascular and neurological diseases to ensure validity of the findings. Screening consisted of various tests for visual acuity, IQ, tapping speed, tachistoscopic presentation (flashing images on a screen), simple and complex reaction times. Once again, three types of cards were used, but with only 17 stimuli each. And again, those over 60 years of age demonstrated a slower reaction time than their younger

counterparts. Study results suggested that the elderly demonstrated deficits in inhibiting words while attending to color characteristics (Cohn, Dustman, & Bradford, 1984).

In the current study, subjects engaged in a similar form of Stroop Color-Word Task, although both stimulus and response mechanisms were automated. Reaction time was measured for all variables, including a control stimulus, congruent and incongruent stimuli, and age of subject. Fastest response time was expected for control stimuli, with congruent and incongruent stimuli getting progressively slower, respectively. It was also expected that age-related factors would contribute to differing reaction times between subjects and that steadily increasing age would contribute to steadily increasing reaction time.

## Method

### Participants

Six subjects (3 female and 3 male) were solicited to participate in the study. All subjects belonged to one of three groups: 20-40 years of age, 41-60 years of age, or 61-75 years of age. Two subjects, 1 male and 1 female, with a mean age of 29.0, were in the 20-40 year-old group; two subjects (1 male, 1 female), with a mean age of 46.2, were in the 41-60 year-old group; and two subjects (1 male, 1 female), with a mean age of 69.3, were in the 61-75 year-old group.

### Apparatus and Materials

An automated Stroop task, color-word version (St. James et al., 1994), was used to conduct the experiment. A standard computer, color monitor, and keyboard were used for all subjects.

### Procedure

All subjects were informed of the nature of the study and provided their informed consent before participating in the trial. Testing occurred at random over a period of ten days. Subjects

were seated in front of a computer workstation and were shown the appropriate response keys on the keyboard. The automated task provided detailed, written instructions on how the experiment would be conducted. The experimenter verbally confirmed understanding of the trial.

Thirty practice rounds were given to acquaint each subject with the procedure and desired response. A fixation point (a '+') appeared on the screen, and instructions were provided to press the spacebar with the left hand to view the colored word or symbols on the screen. Subjects were to ignore the word or symbols and identify the ink color displayed. Entries were made by pressing the matching color patch on the computer's numeric keypad with the index finger of the right hand. Emphasis was placed on responding as quickly as possible, while avoiding errors. Response time was measured in milliseconds. Subjects were given as much time as needed or desired between each trial. An accuracy rate of 80% was required in the practice rounds before beginning the actual experiment.

The experimental task was composed of 3 blocks of 36 trials each, for a total of 108. Subjects were asked to identify ink color on the screen, always ignoring the words or text for each screen. Trial entries were recorded using a computer keyboard, with color-coded numeric keys, as follows: 2 = blue, 4 = green, 6 = red, and 8 = yellow. The total task was composed of 12 control trials, which displayed four "xxxx"s on the screen; 12 congruent trials, with words and ink colors matching; and 12 incongruent trials, in which the words and colors were mismatched (St. James et al., 1994).

At the completion of all 108 trials, individual data reporting was provided on the screen for each condition (congruent, control, and incongruent). A report was given for mean correct reaction time for each condition.

## Results

Scores are reported by individual and age group, with a mean correct reaction time for each (see Tables 1 and 2).

Reaction times for all subjects in all categories consistently showed the fastest response in the control category, with congruent slightly slower, and incongruent the slowest. Subjects showed a steadily increasing reaction time according to age group, with pronounced increase in the over-60 group (see Figures 1 and 2).

## Discussion

The present data support the findings of earlier researchers in the Stroop Color-Word Task with regard to reaction time in the control, congruent, and incongruent categories (Cohen, et al., 1990; Comalli, et al., 1962; St. James, et al., 1994). These findings continue to suggest that attention and interference play major roles in the processing of information, with words (reading) winning the battle for automaticity over color naming.

The data also support the hypothesis that age plays a major role in reaction time to the stimuli, with responses slowing significantly after the age of 60. These findings are similar to those found in age-related studies conducted previously (Cohn et al., 1984; Comalli et al., 1962).

Although all subjects in the current study were given identical workstation conditions for completion of the trial, several factors may be considered to have influenced the outcome. Such factors should be considered in future work: timing of peak performance, general health of subjects, and more flexible manipulation of experimental apparatus.

Peak performance time of individual subjects should be considered when dealing with extremely small incremental reaction times (i.e., milliseconds). Physiological and mental alertness are important factors to results. Time of day was varied from midday to late evening

among subjects tested. The late hour may have contributed to a slower response time in the youngest subject (age 26.0), compared to the response time of the 32-year-old subject.

General health conditions may also contribute to reaction time responses. All subjects are susceptible to illness and times of general fatigue as a normal course of life, and these conditions should be considered before acceptance into the trial. In the current study, one subject was eight months pregnant and reported a general sense of fatigue greater than her normal physiological state. Additionally, elderly subjects are more susceptible to problems with motor control where automated responses are required.

Finally, the manipulation of the experimental apparatus did not allow for flexibility in handedness. The experiment called for subjects to advance to new screens using the left hand on the spacebar, and to press stimulus response keys with the right index finger. Left-handed subjects might be presumed to display slower reaction times when forced to use the right hand for this critical response.

## References

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Table 1

Individual Reaction Time as a Function of Age in the Stroop Color-Word Task

Individual Correct Reaction Time by Age	Condition		
	Congruent	Control	Incongruent
26.0	1008	904	1016
32.0	792	780	826
42.2	755	724	902
50.2	1201	1161	1283
67.25	1429	1307	1470
71.5	1590	1511	1817

Table 2

Mean Reaction Time as a Function of Age in the Stroop Color-Word Task

Age Group	Condition		
	Congruent	Control	Incongruent
20-40			
Mean Correct	900	842	921
Reaction Time			
41-60			
Mean Correct	978	942.5	1092.5
Reaction Time			
61-75			
Mean Correct	1509.5	1409	1643.5
Reaction Time			

Figure 1: Individual reaction time as a function of age.

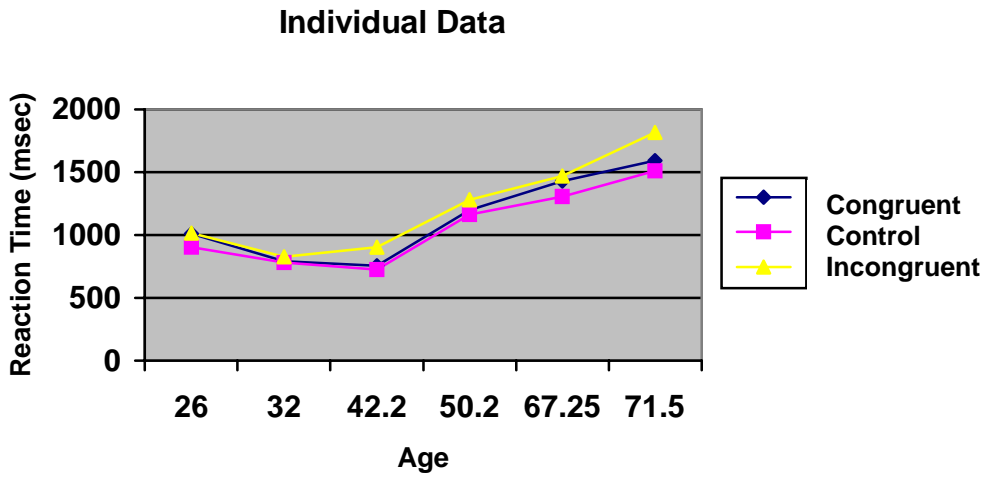


Figure 2: Age group reaction time in the Stroop color-word task.

