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Animal-Word and Sound Test: An Auditory Cognitive Interference Effect

Jason L. Parker
Old Dominion University

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ANIMAL WORD AND SOUND TEST:

AN AUDITORY COGNITIVE INTERFERENCE EFFECT

by

Jason L. Parker
B.S. June 1989, Old Dominion University

A Thesis submitted to the Faculty of
Old Dominion University in Partial Fulfillment of the
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Approved by:

_____
/Perry Duncan (Director)

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Mark Scerbo (Member)

_____
Barry Gillen (Member)

ABSTRACT

ANIMAL WORD AND SOUND TEST:
AN AUDITORY COGNITIVE INTERFERENCE EFFECT

Jason L. Parker
Old Dominion University, 1996
Director: Dr. Perry Duncan

This study presented a method in which the Stroop Color Word Test can be adapted to an auditory form. This auditory test used a series of animal words, animal sounds and word-sound combinations. This "Animal-Word-and-Sound test" contained three subtests. The test tasks were to repeat a list of words, identify a list of animal sounds, and to identify the sound in a combined animal word-sound pairings (Both the animal's name and sound are presented simultaneously). An alternate form of this audio test was examined. The alternate form followed the same construction except in the final condition, the task was to identify the spoken word. Twenty-eight undergraduate college students from Old Dominion University participated in the experiment. A comparison was made between two groups. One group received the Animal Word and Sound Test, the other, received an alternate form of the test. Both groups were given the Stroop Color and Word test for comparison. Participants' response times were recorded, and analyzed by means of a Multiple Analysis of Variance. The results showed that interference can be created from the association of animal names to the corresponding sound that animal makes. Theoretical implications of a comparison to the Stroop test were also discussed.

To my Mother, E. Virginia Parker.

Her support and encouragement gave me the confidence and pride

to complete this project.

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INTRODUCTION

The effect of interference on cognition has been a topic of research that dates back many years. Interference is a conflict of competing associations and response tendencies in learning and memory that is caused by competing thoughts and ideas (Champlin, 1985). A standard test for the study of interference on cognitive processing is the Stroop Color and Word test (Stroop, 1935; Jensen, 1965; MacLeod, 1991). The purpose of the current investigation was to develop and test a method in which the Stroop Color Word Test may be adapted to an auditory form.

Development of the Stroop Color-Word test

In early research on interference, Kline (1921) cited a 1894 study by Muller and Schuman. Muller and Schuman taught subjects to associate certain meanings with nonsense syllables and then asked them to re-associate those syllables to new meanings (Kline, 1921). The results showed that pre learned meanings produced an interference effect in the learning of new material. From their research, Muller and Schuman described the Law of Associative Inhibition, that states, "...if A is already connected with B, then it is difficult to connect it with K, (because)B gets in the way." (Kline, 1921, p. 270.)

The Journal Model used for this Thesis was the Publication Manual of the American Psychological Association, Fourth Edition.

Kline tested the Law of Associative Inhibition. In his research with stimulus associations of states to capitals, and books to authors, he found that strong associations between previously learned items would create an interference effect with newly learned items.

In order to further investigate associative inhibition, Stroop created the test that bears his name (Stroop, 1935). The Stroop Color Word Test uses three subtests that are composed of either words, colors, or color-word mixtures. For the word subtest the stimuli are a list of words printed in black ink, and participants are asked to read aloud the list of words. The words used are actually the names of different colors printed in black ink. In the color subtest people are exposed to blocks of different ink colors and the task is to say the color's name. For the color-word subtest, people are exposed to color words that are printed in a different color of ink. The task is to say the name of the ink rather than to read the printed word. For example if the word "red" were printed in green ink, the correct response would be "green." The incorrect response is "red." The words in this condition are never printed in the color that they represent (see Figure 1).

The results of the Stroop test show that the number of verbal responses a person can complete correctly in a given amount of time is influenced by word reading and color identification associations. A person can say more words than they can name colors, and they can identify more colors than they can say the ink color of color-words. This decrease in performance is attributed to the interference created by word, color and color-word associations. The previously learned skill of reading interferes with a person's ability to name the incongruent color-word pairings. Variants of the Stroop task have

A   Read through this list of color names as quickly as possible.
     Read from right to left across each line.

RED	YELLOW	BLUE	GREEN
RED	GREEN	YELLOW	BLUE
YELLOW	GREEN	BLUE	RED
BLUE	RED	GREEN	YELLOW
RED	GREEN	BLUE	YELLOW

B   Name each of these color patches as quickly as possible.
     Name from left to right across each line.
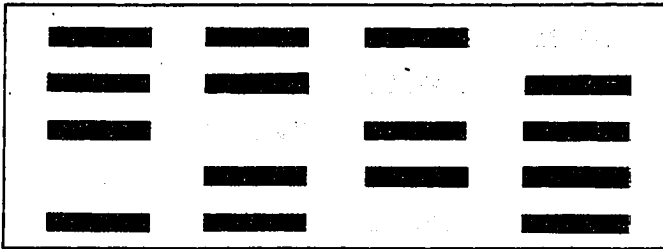
C   Name the color of ink in which each word is printed as quickly as possible.
     Name from left to right across each line.

RED	BLUE		YELLOW
YELLOW		RED	GREEN
BLUE	YELLOW		RED
GREEN	BLUE	YELLOW	
	YELLOW	RED	GREEN

(Coren & Ward, 1989)

Figure 1. A Sample Version of The Stroop Color Word Test.

demonstrated the same results using either response time or number of words as performance measures.

Theoretical Accounts

Stroop (1935) initially explained the interference created by the task as a function of the amount of practice the participants had on the task. Stroop concluded that in the associations that were formed between word reading and color naming, the differences in the speed of a person's reading of words versus the naming of colors may be accounted for by the difference in the training of the two activities.

Since the creation of Stroop's Color and Word test there have been hundreds of studies investigating the "Stroop effect." MacLeod (1991) organized and integrated several theoretical accounts of the Stroop effect. The two theories that are pertinent to the present investigation are the Relative Speed of Processing theory and the Automaticity theory.

The Relative Speed of Processing theory begins with the fact that words are read faster than colors are named. This speed difference causes competition when two potential responses compete to be the response actually produced. The time delay in this competition is caused by interference. This general interpretation is described by MacLeod as an analogy to a horse race. In this race, the response competition is between two race horses. The two responses race against one another for the control of the final output. For this theory MacLeod summarized three key assumptions: (a) parallel processing of the two dimensions of the stimulus at different rates, (b) a limited capacity response channel into which only one of the two potential responses can be admitted at a time with priority of the responses being determined by relative rate of processing, and

(c) priming of the responses is possible from several sources such as preceding trials or other response set elements.

Morton (1969) had previously presented a more elaborate view of the relative speed of processing model. His Compatibility Model states that in the Stroop color and word test, the words tend to be processed more quickly, and therefore, enter the single response channel before the color responses. This response competition is explained as the result of stimulus-response incompatibility. In this view, two factors should theoretically influence response competition: (a) the average speed with which responses to the relevant and irrelevant dimensions of the stimulus occur, and (b) the stimulus-response compatibility of the relevant dimension compared to its response type.

The theoretical view of Automaticity presents a "later selection" account of the Stroop effect (MacLeod, 1991). In this explanation, the processing of one dimension requires a greater amount of attention than does the processing of the other dimensions. Therefore, naming the ink color requires more attention than does read the irrelevant word. It is assumed that this imbalance occurs because people have extensive experience reading words, as opposed to naming ink colors. Basically, words are read automatically, while colors require additional attention to be named.

This Automatic processing theory maintains that a more automatic process can interfere with a less automatic processes. This view is supported by the Perceptual Conflict theory as described by Hock and Egeth (1970). Hock and Egeth suggest that semantic information in the stimulus disrupts the identification or encoding of the ink color by diverting attention from it. The disruptive power of the distractor is proportional to the degree of semantic relatedness between it and the correct response. The subjects,

through this process, become sensitized to words related to the semantic domain of the task.

If these theories accurately depict what is occurring, then a Stroop-like task should not be limited solely to visual color-word tasks. Can this kind of interference be created in an auditory test? In answer to this question two types of audio Stroop tasks have evolved. One test deals with voice-gender identification tasks, the other uses word-pitch combinations to create an audio interference task.

Auditory Analogues to the Stroop

Green and Barber (1981) created an auditory Stroop effect with judgments made of a speaker's gender. In their paradigm, they created stimulus-congruent and stimulus-incongruent situations concerning the gender of the speaker, and the gender word spoken. The congruent conditions for the study consisted of a male saying "male" and a female saying "girl." The incongruent stimulus presented was the recording of a male saying "girl" and a female saying "male." This study also used what Green and Barber described as, "pseudo-congruent" and "pseudo-incongruent" stimuli that were identified as the words "mill" and "game." These stimuli were presented to participants on audio tape and their response times were measured. The results indicated that an interference Stroop effect could be created in an audio task.

While Green and Barber's test did create interference, there are problems with the way the test was constructed. In their audio task, participants were asked to identify the gender of the speaker. This was the task for all subtests. In the non-interference condition either a man said "man" or a woman said "girl." In the interference condition either a man said "girl" or a woman said "man." This response pattern does not compare

to the Stroop test, which asks participants to read a list of words in one subtest, then say the colors of ink samples in the next subtest, and then identify the color of a word-color (interference) pairing. The Stroop deals with two different tasks. Two questions to be raised are what is pseudo-congruent and pseudo-incongruent? And how is that related to the Stroop effect? Green and Barber had both the male and female speaker present the words "mill" and "game" to the participants as a control measure. The man saying "mill" was considered to be pseudo-congruent, and the word "game" pseudo-incongruent (the opposite was true for the female speaker). The task was still to identify the gender of the speaker. The problem with this control measure is that its underlying assumption is that people are more automatized to identifying the gender of the speaker, than to listen to what they are saying (Green and Barber, 1981). To create a control to compare to the incongruent gender-word pairings (man saying "girl," woman saying "man") a task should be used that parallels Stroop's task of reading words printed in black. To parallel Stroop's reading aloud task, subjects should listen to the spoken word and repeat what was said; in effect, read the spoken word. Another problem with the Green and Barber "man-girl" paradigm is that the task is basically a binary decision. The answer to all of the subtests is either man or girl.

In a similar study Jerger, Martin and Pirozzolo (1988) created an auditory Stroop task for children using combinations of "mommy" and "daddy." In the study forty-eight children from the age of three to six were asked to respond manually as quickly and accurately as possible to words spoken by a male or female voice. The subjects were asked to ignore what was said by the speaker and to push the "mommy" button if a mommy spoke or "daddy" when daddy spoke. Responses were measured in a fashion

similar to that of Green and Barber (1981) according to congruent (female saying "mommy" or male saying "daddy") neutral (both voices saying "baseball" or "ice cream") and incongruent (male saying "mommy" or female saying "daddy") conditions. The results showed that children are automatized to attend to the spoken word. The subjects showed a significant effect for the incongruent interference condition as well as for the stimulus neutral condition.

These findings illustrate that some sort of interference can be obtained through the use of a gender-based, incongruent pairing. But the significance of the "neutral" stimuli shows that other less clearly defined associations may create an effect outside of the parameters of a Stroop effect. This is an indicator of the problems this study shares with Green and Barber's (1981) design. The stimuli group cannot be reapplied to Stroop's paradigm. The congruent and neutral groups do not show the same cross-group associations that printed words of color names and blocks of ink color do.

Hamers and Lambert (1972) also created an auditory analogue to the Stroop test to investigate bilingual interdependencies in auditory perception. For their study they constructed an auditory and bilingual version of the Stroop test. In their audio test design, they used the words "high" and "low" in both English and French. These tests were both constructed using two subtests. One subtest used the words "high" spoken in a high tone, and "low" spoken in a low tone. The other, interference subtest utilized the words "high" spoken in a low tone, and "low," said in a high tone.

The tests were given in both languages to bilingual subjects who responded in both French and English conditions. The participants were asked to respond to the

physical characteristics of a speaker's voice and to ignore the words that were spoken. Participants responded in either verbal or manual key press conditions.

The results showed that interference can be created through audition. Incongruent word and sound pairings ("high" in low pitch) took longer to respond to than congruent pairs ("low" said in low pitch). There was no difference between the English and French language, but there was a difference between verbal and manual responses. In all conditions, the response times for verbal stimuli were always longer than for the key press responses.

Cohen and Martin (1975) have provided support for the effectiveness of the "high-low" design with their study on hemispheric differences in an auditory Stroop. In their experiment participants were asked to respond manually to auditory stimuli. The auditory stimuli used were separated into three subtests. A high tone (600Hz) and a low tone (400Hz) stimulus group was one subtest. Another subtest used the word "high" sung in a high voice, and "low" sung in a low voice. The other condition used the word "low" sung in a high pitch, and "high" sung in a low pitch. These stimuli were presented to the participants monaurally, randomly alternating from ear to ear in all three subtests. The task for all three conditions was to identify the pitch of the word or tone that they heard. The manual responses to be made were to press a "high" key with one hand and a "low" key with the other hand. To control for handedness a screening test was given to participants and they were randomly separated into two groups. The groups contained an equal number of right handed and left-handed subjects.

The results of Cohen and Martin's (1975) study showed differences in the response times among the three subtests. Identical word pitch combinations (e.g., "high"

sung in a high pitch) gave the fastest response times. The tone condition gave the next fastest time, and the word-pitch, incongruent stimulus condition (i.e., "high" sung in a low pitch) was the slowest. As in the Green and Barber (1981) study, a problem with this design concerns the way that the audio Stroop task was constructed. Specifically, the participants were asked to complete the same task for each of the subtests. The task in those studies was to identify the pitch, in a word or tone or word-pitch task. There is also the use of the "congruent" condition, a condition that has no analogous comparison to the Stroop test for which this test should be based. There is also the problem of giving the subject a "binary" choice. The subject's response on any one item is limited. This limitation may increase the effect of chance on the subject's response.

Cohen and Martin (1975) also theorized that there may be an increase in response time for the dominant hemisphere of the brain when linguistic and non-linguistic content conflict. Morgan and Brandt (1989) investigated this question in their study of an auditory Stroop effect for pitch, loudness and time.

In their study, Morgan and Brandt (1989) measured the manual response times of 21 subjects on auditory lists of conflicting and neutral stimuli. For pitch, they used congruent and incongruent variations of a verbal high and low tone of various words such as "high" and "low," "up" and "down" as well as "top" and "bottom." For loudness the list consisted of words again labeled as incongruent\congruent and neutral that were presented in varying degrees of volume. The condition measuring time presented stimuli at varying durations with words such as fast, slow, run, walk, long, and short. These Stroop stimuli were then mixed with a listing of normal words such as cat, dog, Dave, Joan, mill, and game. These stimuli were randomly mixed and presented to the subject

monaurally as a singular test list. Each subject completed the test list three times. The results showed that it is possible to create an interference task for both pitch and loudness. No effect was found for duration. These results provide additional support for other researchers' investigations of an auditory Stroop effect. They also show that interference can be created by manipulating subjects' perceptions of loudness. Morgan and Brandt also looked at the reaction times according to whether they received a right-ear or left-ear presentation. They found that ear presentation did not significantly influence the processing time of subjects on experimental stimuli. This result is also supported by a study conducted by the author of the current investigation. Parker (1991) examined auditory orientation with judgment towards the speaker. The subjects for the experiment were 12 undergraduate college students from Old Dominion University. For this auditory Stroop task, subjects were required to respond to right and left ear stimulus presentations played into corresponding (congruent) or opposite (incongruent) ears. The stimulus congruent condition presented the word "left" into the left ear and the word "right" into the right ear. The incongruent stimulus conditions presented the word "left" into the right ear and the word "right" into the left ear. No significant effect of interference related to right and left orientation was found.

McClain (1983) investigated stimulus-response compatibility effects on auditory Stroop interference. This audio test used the words "high" and "low" sung in either "high" or "low" pitches. This test was designed with two dimensions; word/pitch and congruent/incongruent conditions. The congruent conditions being the word "high" sung in a high pitch, and "low" sung in a low pitch. In the incongruent condition, the "high" was sung in a low pitch, and the word "low" was sung in a high pitch.

Subjects responded verbally, either by pressing a button, or by humming. The results showed that for both dimensions (word and pitch) and stimulus type (congruent and incongruent) there was a significant difference. McClain (1983) has demonstrated that interference can be created through auditory input, and the type of response required also effects the subjects' reaction time.

In all test conditions, the button press was the fastest, the hum response was second, and the verbal responses were the slowest. This study illustrates that the type of response a subject makes does affect the amount of interference in cognitive processing. In a "Stroop-like" task, verbal responses produce a greater level of interference. At this point in research, the type of stimulus input, visual or auditory, does appear to influence the interference that a test may create. In the investigation of interference processing, the verbal response seems to be more greatly influenced by stimulus-incompatibility to a greater degree than a manual response.

Verbal or Manual Response

The studies previously cited now bring to question what type of response modality is needed in the creation of an audio task. Green and Barber (1983) conducted an additional study again using the man\girl, gender paradigm as in their 1981 experiment. In this study they conducted two experiments to investigate the effect of verbal and manual response latencies in their audio Stroop task. In this study they presented the same test stimuli as in their previous experiment. They found an interference effect for both verbal and manual response conditions. Of interest to this current investigation, Green and Barber also found that the pattern of interference obtained in their study varied according to the response modality used. The verbal condition created a greater degree of

interference than the manual condition. In fact, Green and Barber emphasized the potentially greater sensitivity of vocal responses to response-set interference effects.

Hamers and Lambert (1972) and McClain (1983) also found a difference in response modality between verbal and manual conditions. The significance of these studies is that there appears to be a definite difference in reaction time due to the type of subject response required, with the verbal response causing a larger degree of interference. This effect is not solely found in auditory analogues. Differences in verbal-manual responses have also been found with the Stroop Color and Word test.

Wheeler (1977) conducted a study in which subjects took two forms of a Color Word Stroop task. In the experiment, participants were presented a sequence of color names printed in random colors of ink. The participants read through the Stroop stimuli in two conditions. In one condition participants read the words aloud. In the other condition they responded manually by pushing a button. In a comparison between the two groups there was an interference effect for verbal responses but not for manual responses. This suggests that the interference is in the verbalization of responses. This conclusion is supported in MacLeod's (1991) review of the Color Word Stroop. MacLeod theorized that the Stroop stimuli may activate an automatic verbal processing response. In summary, MacLeod stated that when response modality is switched from oral to manual, interference is reduced. If this is the case, any test task designed to create a "Stroop" effect should require a verbal response because a manual response might not be sensitive to subtle interference effects.

In light of these findings, this current study on auditory interference employed only the verbal response method. This was done because the goal of this experiment was

not merely to show that an audio Stroop effect can be created. The existence of such an effect has been established (Green and Barber, 1981; McClain, 1983; Hamers and Lambert, 1972). These researchers have created an interference task, but not a true analogue to the Stroop. Thus, a primary goal of this experiment was to create an auditory test that more closely parallels the SCWT (Stroop Color and Word Test). Another issue this experiment addressed was the number of stimulus items used in the design.

<u>Number of Stimuli</u>

In the previous research on auditory interference, experimenters have used test forms that at their basic level ask for a binomial response. The answer is one or the other. (Green and Barber, 1981; McLean, 1983; Hamers and Lambert, 1971).

The question of the effect of the number of items on the Stroop Color and Word Test was asked by Golden (1974), who investigated the effect of three, four, and five colors on the SCWT. The standardized forms of the test were given and a between-groups design utilized. No significant differences were found so Golden concluded that the number of colors had little effect on Stroop performance. But in Golden's study the relationship of a two-color test to a three, four or five color test was not investigated.

<u>A Two Color Color-Word Test</u>

In an unpublished study by this author (Parker, 1992), a comparison of a two-color Stroop task was made to the SCWT. The test utilized in this experiment was constructed using only the colors blue and red. These colors were randomly arranged in blocks of six for a total of 30 items. As in the SCWT, subjects were asked to read a list of words, then a list of colors, and finally a list of color-words printed in incongruent ink colors. The color "blue" was printed in red ink, the color "red" was printed in blue ink.

This group of participants were then compared to a second group which received a three color version of the SCWT. The number of items completed by subjects in forty-five seconds were analyzed. The results of this study showed that there was a significant main effect for all the subtest conditions. Word reading was the fastest, followed by color naming, and then by naming the color of color-word pairs for both two and three color tests. Of interest to the current investigation, the number of colors (two colors or three colors) was also significant. It appears that reducing the number of selections to a dichotic set creates a significantly different instrument. Of special importance is the significant interaction of the subtest condition and the number of colors. Although it has been shown that interference was created with a two-color task, the number of items used clearly influenced the sensitivity of the test. This study demonstrated that when reduced to a dichotic choice the test creates significantly different response latencies. A two-item stimulus test is a less sensitive test. In order to create the strongest measurable difference, it is advantageous to create a task that can utilize multiple stimuli.

Problems with Audio Stroops

In reviewing the various constructions of the audio Stroop, several major errors surface. All the audio Stroops that have been used in research share many of the same design flaws.

The flaws in designing an auditory paradigm are: (a) The use of a "congruent" condition. These audio tests have used items like the word "high" sung in a high pitch. This congruent condition, used as a control, is not equivalent to that used in the Stroop word reading condition (See Table 1). In Stroop's control condition, participants read words printed in a neutral color, black, not in a congruent color. For example, the

Table 1

A Comparison of Test Association Stimuli

	A	K	I	C	T	P-C	P-I
Stroop (1935)	X	X	X				
Green and Barber (1981)			X	X		X	X
Hamers and Lambert (1971)			X	X	X		
Cohen and Martin (1975)			X	X	X		
Morgan and Brandt (1989)			X	X	X		
McClain (1983)			X	X			
Jerger, Martin and Pirozzolo (1988)			X	X		X	X
Parker (1996)	X	X	X				

KEY

A = A associated to B
K = New association K
I = Interference of A with K (Incongruent)
C = Congruent
T = Control
P-C = Pseudo-congruent
P-I = Pseudo-incongruent

"congruent item" for the word "red," would be to print that item in red ink. (b) The audio

Stroops utilize a two-item identification task. This limited number of stimuli gives the

subject a binary set. While Golden (1974) has shown that there is no difference between

a three, four, and five item task, the reliability of a two-item "Stroop" task has not been

firmly established. (c) The use of a manual response. The button press, manual response

has been shown to be a less accurate measure of the Stroop effect. There is a difference

in interference processing that can be attributed to the response modality (McClain, 1983;

Wheeler, 1977). (d) The use of the mixed stimulus list for the interference condition (See

Table 1). For example, a mixed list being used as in Green and Barber's (1981) study

with the word "man" said by a man, and "girl" said by a woman. These words were

mixed into the interference group containing the word "man" spoken by the female, and

"girl" spoken by the male. That mixed use of stimuli would be equivalent to the Stroop

test printing the word "red" in red ink and mixing that into the color-word (i.e., "red"

printed in green or blue ink) list. In Stroop's (1935) original design, he specifically

designed the task so that no word was printed in the color it named. The use of this

mixed list is also found in Hamers and Lambert (1972), Cohen and Martin (1975), and

McClain's (1983) experiments. (e) The audio analogues previously cited have also asked

participants to do the same associated task for all stimulus items. To illustrate the

significance of this error, this experimenter has reexamined Stroop's Color and Word test.

Stroop's approach in his initial research was to apply Muller and Schuman's Law

of Associative Inhibition. To summarize how the Stroop Color and word test relates to

the law, if A (i.e., seeing a color word) is already connected with B (reading a color

word), then it is difficult to connect A (seeing a color word) with K (saying an unrelated

color name). Note that Stroop's condition of correct naming of a colored block of ink is not included above because it is essentially a perceptual control. In order to test the theory, three different actions need to be evaluated. Previous auditory Stroop tasks have followed a different model. For example, if the tasks by Hamers and Lambert (1972), Cohen and Martin (1975), and McClain (1983) were plugged into the formula above, the results would not even be applicable. The formula that would fit is, if A (hear pitch word such as "high") is already connected with B (recognize related pitch of tone) then it is difficult to connect A (hear pitch word) with (. . . condition not existing) rather than the · formula for the Law of Associative Inhibition. If A is associated with B, then Associating A with K is difficult.

The simplest approach to testing an analogous effect is to use the same theory, design, and formula as the model. In the designs of the auditory Stroop tasks previously reviewed, researchers take an association (such as gender identification or stimulus pitch identification) and create no new association. This brings to question whether these audio tasks are actually identifying interference caused by competing responses.

This is apparent when the stroop effect is considered to be the result of interference occurring in the output channel. If the effect is happening in the output (vocalization), then by holding the interference formula constant it is possible to change the modality from visual to auditory, and create an identical effect. To this, in terms of Perceptual Conflict theory, the Stroop shows a linguistic element (words) that are semantically related to a non-linguistic element (colored blocks). The combining of those elements creates an interference task (color-words). To apply this to an auditory task one would require an initial linguistic descriptor (i.e., a spoken word), that could be combined

with a non-linguistic element (a sound) that is described and related to the word. The combination of these elements would then create an interference task that should parallel Stroop's task.

Design of Animal Word and Sound Test

In light of these findings it became apparent that in an auditory paradigm, more than two items should be used. In the current experiment, a method in which a multiple item audio test may be constructed was examined. This audio test was used to explore the assumption that people are automatized to listen to the spoken word, much the same as people are automatized toward reading words, and responding in a more deliberate manner when identifying other, nonverbal stimuli that are present. Just as automaticity theories hypothesize that people's experience in reading primes them for the color-word interference effect, this experimenter believes that we are primed to listen to words that are spoken to us. This auditory, word priming then leads to a word-sound interference effect.

Research has shown that cognitive performance is affected by visual identification and verbal response of word, color and word-color incongruencies (Jensen, 1965; Stroop 1935). More recent research suggests that a similar effect exists with words that are experienced via the auditory modality. This study investigated the effects of multiple stimuli on responses to animal words and sounds. To illustrate this phenomenon, an analog of the Stroop Color and Word test was used to create an auditory interference effect. The purpose of this experiment, was to develop an auditory task that parallels the Stroop Color and Word Test. The protocol developed to achieve this purpose employed recorded lists of animal names (animal words), animal sounds (e.g., a barking dog), and

word-sound combinations. The Animal Word and Sound test (AWST) that was created,

consisted of three sub groups: a stimulus word group, a sound group, and a combined

word-sound stimulus group. In the first condition, participants were asked to repeat the

word spoken to them. In the second condition participants heard a series of animal

sounds, and were asked to name the animal that they heard. In the final condition

participants heard both the spoken "animal word" and "animal sound" simultaneously.

The task was to identify the "animal sound" and to ignore the spoken word (see Table 2).

        To test the assumption that people are automatized to preferentially respond to

spoken words, an alternative form of the AWST was administered. In the AWST-A (for

alternate form) the first two conditions remained the same. To determine whether the

word or the sound was the cause of the interference, the third condition asked participants

to identify (repeat) the spoken word. This tested whether the "word" is the faster

response. The experiment also included a version of the Stroop Color and Word test,

which was given to both groups of participants for the purpose of comparison.

        The presentation of these tests created a 2 (group) X 2 (task) X 3 (condition)

mixed factorial design. The one between subject factor had two levels represented by

group (AWST or AWST-A) the within-subject factor of task also had two conditions: the

type of test (auditory or visual) and the condition which included three subtests (written

word/spoken word, color/sound, color-word/word-sound). All subjects received all six

combinations of task and condition, but in conjunction with only one of the groups

(AWST or AWST-A). In summary, the independent variables in this design were

Table 2

A Comparison of Experimental Paradigms

Test Task (Required Response)

	Stroop	AWST	AWST-A
Condition 1	Read Word	Repeat Word	Repeat Word
Condition 2	Read Color	Repeat Sound	Repeat Sound
Condition 3	Read Color	Repeat Sound	Repeat Word

"group," "task" and "condition." The dependent measures were the subjects' response times on each subtest condition.

Hypothesis

Differences were expected in mean response times between the spoken word condition, the animal sound condition, and the combined word-sound condition. The specific prediction was that the word group would produce the fastest response time, followed by the animal sound condition, with the word-sound condition producing the slowest response times of all groups. Also expected was a difference between the AWST's third condition and that of the third subtest of the AWST-A was expected. The third subtest of the Animal Word and Sound test was expected to have a greater mean response time than the AWST-A.

METHOD

Subjects

The participants for this experiment were 28 undergraduate students from Old

Dominion University in Norfolk, Virginia. The use of human subjects was approved of

by the Univesities Human Subjects Review Board (see Appendix A). The age range was

between 18 and 35 years with an equal number of males and females in each group. All

subjects participated with informed consent (see Appendix B). Incentive for participation

was provided by offering one credit point to subjects for taking part in the experiment.

Criteria for participation were: Corrected visual acuity 20/20, no known color blindness

as tested by the Coren and Hakstian (1988) Color Screening Inventory (see Appendix C),

and no known hearing impairment.

Materials

The Animal Word and Sound Test was recorded on an AMPEX ACE 25

audio/video computer editor. The stimuli were selected from a commercial CD (Network

CD sound effects library). The animals (both words and sounds) used were dog, bird, and

cat. Words chosen consisted of one syllable. The words dog, cat, and bird were also

chosen because they did not repeat the same phonemes. The sounds were then recorded

on audio/video tape at a speed of 30 frames per second sampled at 110 db and 44kHz.

The recorded stimuli were arranged and edited on an IBM PS/2 model 30 286 with a

Sound Blaster Pro audio card with volume set at CD quality level (110 db and 44kHz,

and a 16-bit sampling rate). The editing program was a Master FX editor in EZ Sound

Pro. Each stimulus sound was presented for approximately .5 seconds with an

interstimulus interval of 1.0 second. These sound stimuli were then arranged in random order to create the various subtests.

Subtest one (word) and subtest two (sound) task items were constructed by random selection without replacement in blocks of three. No two identical items appeared in succession. Subtest three (word-sound pairs) was constructed in blocks of six. A block of six was created by adding together all possible word and sound combinations. Combinations containing the same animal word and animal sound were omitted. The items were then randomly selected without replacement, and again no two identical items appeared in succession (see Appendix E). These items were then recorded on audio tape for presentation.

Apparatus

Auditory stimuli were presented on a Sharp WQ-T360 stereo radio cassette player-recorder. The Sharp recorder also contained a cartoid microphone for the recording the subjects' responses, using the recorder's dubbing function. The participants heard the test tape over a pair of stereo headphones and spoke into the microphone, creating a tape containing both the stimulus and the response items. The Stoelting company version of the Stroop Color and Word test was used (Golden, 1978, see Appendix G).

Procedure

The participants were greeted by the experimenter and given the Color Vision Screening inventory by Coren and Hakstian (1988). Demographic information on the subjects was also collected at this time. The participants were then briefed on the

Table 3

Mean Duration of Stimulus Items

(1). Animal words used.

Word	Frames per second	Time (in seconds)
Cat	19/30	.63
Dog	13/30	.43
Bird	14/30	.46

Mean time for animal words = .51 second.

(2). Animal sounds used.

Sound	Frames per second	Time (in seconds)
Cat	16/30	.53
Dog	14/30	.46
Bird	17/30	.56

Mean time of animal sounds used = .52 seconds.

(3). Animal word - animal sound combinations used.

Word-sound	Frames per second	Time (in seconds)
Cat-Dog	16/30	.53
Cat-Bird	16/30	.53
Dog-Bird	14/30	.46
Dog-Cat	19/30	.63
Bird-Cat	19/30	.63
Bird-Dog	17/30	.56

Mean time for word-sound combinations used = .56 seconds

experiment and given the opportunity to ask questions. An Informed Consent form was then signed and collected.

The subjects were separated into two groups (AWST, AWST-A) through random assignment. There were fourteen members in each group. The groups were balanced for gender with eight females and six males in each group. For the AWST group, participants were asked to (a) repeat a list of words (animal names), (b) identify a list of animal sounds and, (c) identify the animal sound in a combination of Animal-Word and Animal-Sound pairings. The AWST-A group participants were asked to (a) repeat the list of words (animal names); (b) Identify the list of animal sounds and (c) identify the animal word in a combination of Animal-Word and Animal-Sound pairings (see Appendix D). Both groups received the Stroop Color and Word Test (SCWT). In this test, participants were asked to: (a) Read a list of words, (b) Read a list of colors, and (c) read a combination of color-word pairings (see Appendix F). The order which the subjects received the test tasks (auditory or visual) was counterbalanced to control for possible learning effects.

The instructions for the AWST and AWST-A tasks were played from the previously recorded test tape. (see Appendix D). The verbal responses were then recorded on audio tape. Upon completion of all tasks, subjects were debriefed and given an opportunity to ask questions about the test.

<center>RESULTS</center>

The response times for the animal word and sound test were derived by measuring the stimulus onset asynchrocy (SOA). For this experiment the SOA was defined as the time between the beginning of the audio test stimuli to the beginning of the subjects' responses. The SOA was measured by transferring each subject's test tape into an IBM p/s 2 model 30 286, with a creative Sound Labs Sound Blaster Pro sound card. The sound wave was then measured utilizing the EZ sound FX program by Future Trends Software Inc.

Master FX is a utility function of EZ sound FX that allows the duration of a sound stimulus to be measured at a resolution of one ten thousandth of a second. This was done by measuring the distance from the onset of the stimulus to the onset of the response for each of the subject's responses. The raw data were then compiled and mean response times were calculated for each condition. For the audio tests (AWST and AWST-A) mean response times were calculated for the word, sound, and word-sound combination condition for each subject. The subjects' scores from the SCWT were converted mathematically to create a comparative mean response time score. This function was calculated by taking the total number of items completed by each subject and dividing that by the total amount of time given for each test condition. Response time equals the number of items/45 seconds. For all of the analyses the alpha value was set at the .05 level. A three-factor mixed analysis of variance with repeated measures on two of the factors was employed to analyze the data. The between-subject variable had two levels corresponding to the two groups. The two within-subject variables were the tasks at two levels and conditions at three levels. For the between variable, group number denoted
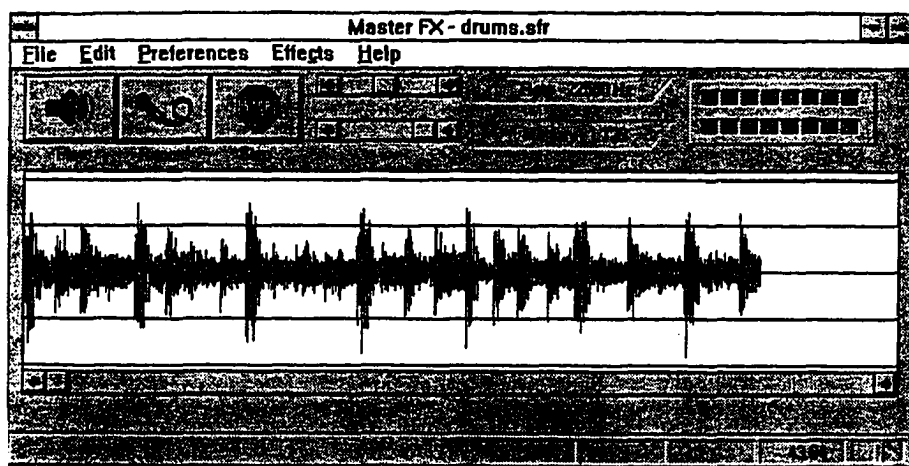
Figure 2. Sample EZ Sound Pro, Master FX Sound Wave.

which test group the subject participated in. Group one included the subjects who

received the AWST and the SCWT. Group two consisted of the subjects who received

the alternative form of the audio test, AWST-A, and the SCWT. For the within variables

of task and condition, the two tasks were the two forms of the test, auditory and visual.

The three levels of condition were the three sub test conditions of each test:

AWST/AWST-A; word, sound and word-sound; for the SCWT; word, color and color-

word. To simplify the descriptions, the three sub tests will be referred to as simply

condition one, two, and three.

The results of the ANOVA (See Table 4) failed to show a significant main effect

for the variable of group. There was no significant difference in the scores of the auditory

and visual tests between the two groups. For the variable of task no significant difference

was found. Subjects' scores did not differ according to which test task they were given.

There was no significant interaction between group and task.

For the within-subjects variable of condition a significant main effect was found,

$F(2, 52)=192.97$, $p<.05$. Subject's scores differed within each of the three conditions.

A significant interaction was found between group and condition, $F(2, 52)=16.93$,

$p<.05$. Subjects' scores varied according to which group AWST and SCWT or AWST-A

and SCWT, depending on the three test conditions. There was also a significant

interaction detected between task and condition, $F(2, 52)=59.89$, $p<.05$. This indicated

that the effect of the three conditions depended on whether the tasks were auditory or

visual. A second order interaction between the factors of group, task and condition was

also detected $F(2, 52)=7.74$, $p<.05$. The subjects' performance on the three subtest

Table 4

Summary Table of Three-Way Mixed Analysis of Variance.

Source	df	Mean Squares	F
Between subjects			
Group	1	0.07792483	2.62
Error			
Subject(group)	26	0.02978277	
Within subjects			
Task	1	0.00208469	0.09
Group*Task	1	0.05300152	0.26
Error			
Task*Subject(group)	26	0.02343116	
●Condition	2	2.68262491	192.97
●Group*Condition	2	0.23541428	16.93
Error			
Condition*Subject(group)	52	0.01390177	
●Task*Condition	2	0.67770342	59.89
●Group*Task*Condition	2	0.08758224	7.74
Error			
Task*Condition*Subject(group)	52	0.01131665	

Note: ● = significant value.   p<.05

conditions was influenced according to which tasks were given in relation to the group in which they participated.

In order to determine specifically how the three conditions differed, a Tukey HSD test was used. These results are shown in Figure 3. The Figure illustrates how the subjects' mean performance was fastest in the word condition ($\bar{x}$ =.5089 sec). This was followed by the performance of the subjects on the Sound/Color condition ($\bar{x}$ =.7005 sec). The longest mean response times were connected with the Interference condition ($\bar{x}$ =.9456 sec). While this demonstrates the presence of a difference among the subtest conditions, it is a pooled score of AWST and SCWT data. Therefore, the location of that difference, and at what level, is still unidentified. Figure 3 shows a combination of scores consisting of AWST, AWST-A and SCWT data. The Tukey HSD detected no differences by group or task.

To investigate where these differences occur it was necessary to calculate the simple effects for the three-way interaction of group, task and condition. Simple effects were calculated using the methods described by Keppel and Zedeck (1989).

Table 5 shows the simple effects that were calculated for each "cell" in the experimental design. The simple effects of condition for the different levels of task and group showed that there was a difference in the performance of subjects on the three conditions of all tests. In post hoc comparisons for the AWST (see Figure 4, panel a) and both versions of the SCWT (see Figure 4, panel b and d) condition 1 was not equal to condition 2. Condition 2 was not equal to condition 3 and condition 1 was not equal to condition 3. The three conditions of the AWST were significantly
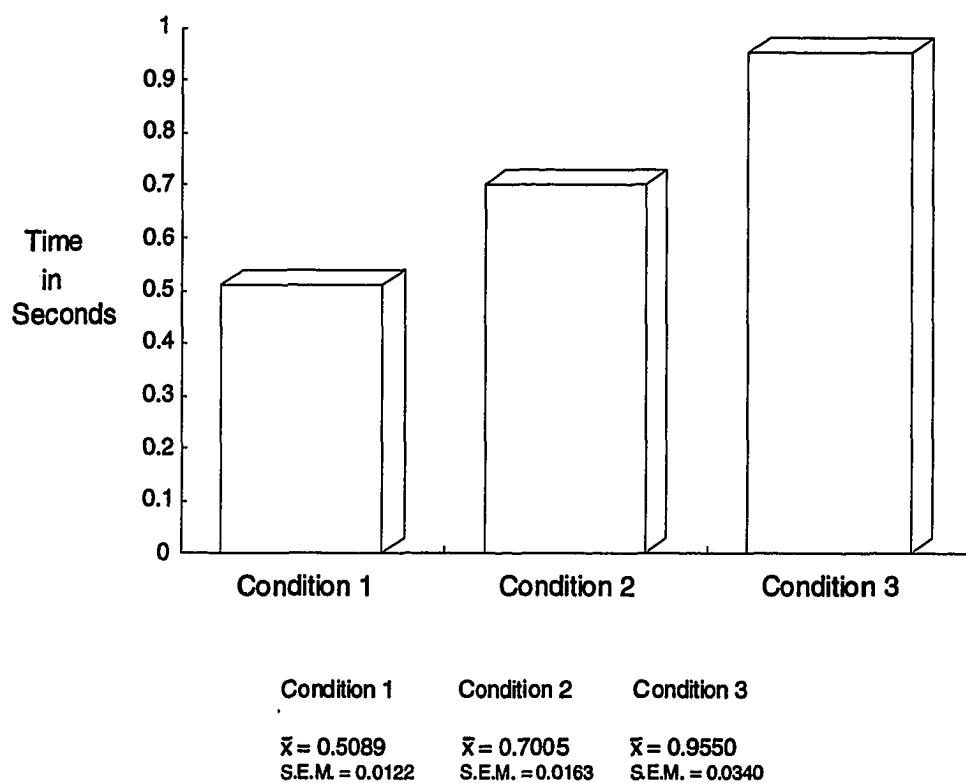
Condition 1   Condition 2   Condition 3

$\bar{X}$ = 0.5089 $\bar{X}$ = 0.7005 $\bar{X}$ = 0.9550
S.E.M. = 0.0122   S.E.M. = 0.0163   S.E.M. = 0.0340

Figure 3. Comparison of Mean Response Times of the Three Subtest Conditions.

Table 5

Simple Effects for Three-Way interaction.

Effect	df	Mean Square	F
Condition for level Task 1, Group 1	2	0.638948	56.46●
Condition for level Task 1, Group 2	2	0.137384	12.14●
Condition for level Task 2, Group 1	2	1.691345	149.46●
Condition for level Task 2, Group 2	2	1.215647	107.42●
Group at level Task 1, Condition 1	1	0.011192	0.99
Group at level Task 1, Condition 2	1	0.013068	1.15
Group at level Task 1, Condition 3	1	0.712263	62.94●
Group at level Task 2, Condition 1	1	0.009318	0.82
Group at level Task 2, Condition 2	1	0.000355	0.03
Group at level Task 2, Condition 3	1	0.030724	2.71
Error Task*Condition*Subject(group)	52	0.011316	
Task at level Condition 1, Group 1	1	0.094726	4.04
Task at level Condition 2, Group 1	1	0.075463	3.22
Task at level Condition 3, Group 1	1	0.127049	5.42●
Task at level Condition 1, Group 2	1	0.100512	4.28
Task at level Condition 2, Group 2	1	0.137046	5.84●
Task at level Condition 3, Group 2	1	1.050861	44.83●
Error Task*Subject(group)	26	0.023431	

KEY
Group 1 =AWST & SCWT
Group 2 =AWST-A & SCWT
Task 1= Auditory test
Task 2= Visual test

● Significant at $p<.05$

different from each other. The two measures of the SCWT also showed differences according to their sub conditions. A Tukey HSD was calculated for the individual cell means. The result of the Tukey HSD showed a significant difference between the means on all three conditions for all subtests on the AWST and for both trials of the SCWT. In the AWST-A the Tukey HSD showed a difference in the mean scores between condition one and condition two and a difference between condition two and condition three but no difference was found between condition one and condition three (see Figure 4, panel c). Subjects responded in the same duration of time whether asked to repeat the word (animal name) in the word identification condition or identify the word (animal name) in the combined word-sound pairing.

As Figure 5 illustrates, there was an interesting shift in mean response times across the three conditions. Of interest here are the differences in the performance of the groups according to each task and condition. As shown in Table 5, subjects' response times did not differ significantly on the AWST in its first two conditions. Subjects in the animal word (naming) and sound identification conditions completed the subtest in an equivalent period of time. Condition one ($\bar{x}$ = .5480 sec to $\bar{x}$ =.5880 sec) and ($\bar{x}$= .7398 sec to $\bar{x}$ = .7830 sec) for condition two. But the simple effect did show a difference on the auditory tasks in the third, word-sound condition.

In Figure 5, mean scores provided by the Tukey HSD were used to compare the two versions of the AWST. As the findings show, whether the subjects were
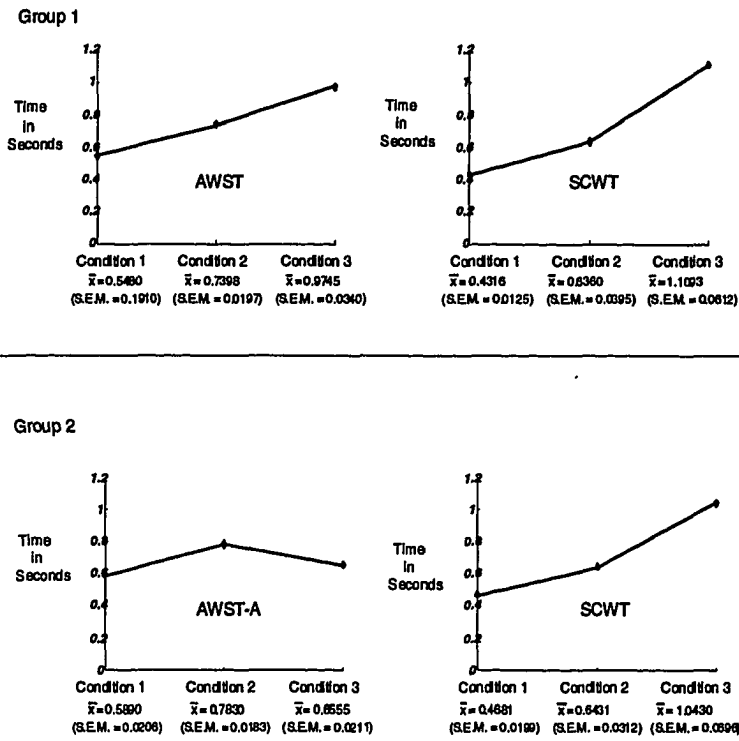
Figure 4. Individual Comparisons of Subtests by Group Assignment and Test Task.

asked to identify the animal sound ($\bar{x}$ =.9745 sec SEM = 0.0340) animals' word name ($\bar{x}$ =.6555 sec SEM = 0.0211) amount of time necessary to respond. It was more difficult to identify the animal sound and to ignore the spoken word than it was to repeat the spoken word while ignoring the animals sound.

The simple effects for group by the second level of task (visual, SCWT) yielded no significant differences. The subjects in both groups performed the same on the identical versions of the SCWT.

The simple effects, for task at all levels of group and condition, yielded a no significant effect for condition one (see Table 5). The simple effect for task at condition two group one, was approaching significance and was significant for task, at level condition 2 group 2 (see Table 5). There was a significant difference in the simple effects for task at level condition three, group one and for task at condition three group two. These findings illustrate that while initially no difference was found according to test task, auditory or visual, there was a significant difference in the performance on the individual auditory and visual tests. The participants' response times were different on each subtest condition and at each group factor level. The AWST was not equivalent to the AWST-A scores in all subtest conditions. Additionally, the AWST and the AWST-A performance were not equivalent to the SCWT performance at all levels.
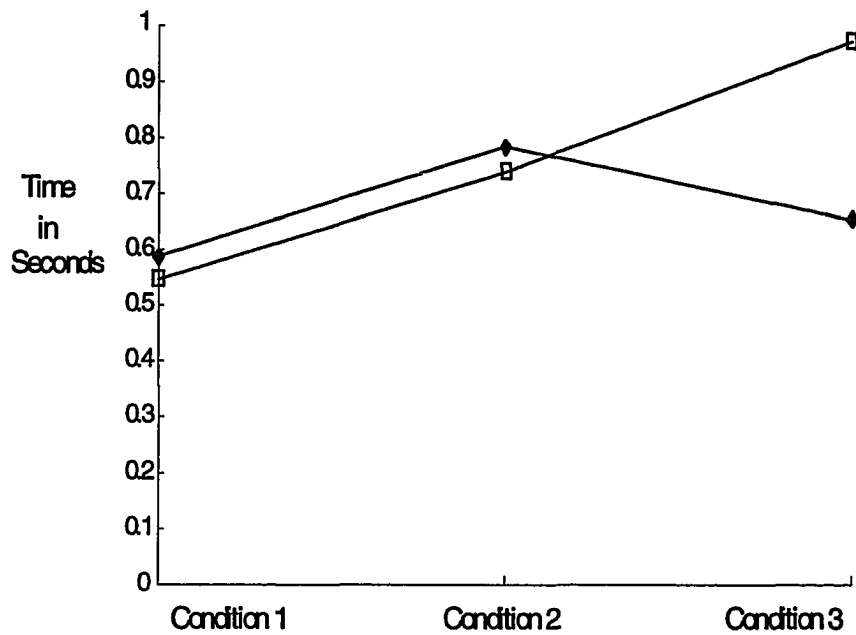
	Condition 1	Condition 2	Condition 3
□ AWST	X̄=0.5480 S.E.M.=0.0191	X̄=0.7398 S.E.M.=0.0197	X̄=0.9745 S.E.M.=0.0340
◆ AWST-A	X̄=0.5098 S.E.M.=0.0122	X̄=0.7005 S.E.M.=0.0163	X̄=0.0456 S.E.M.=0.0339

Figure 5. Comparison of Response Times of AWST to AWST-A.

DISCUSSION

These results illustrate that by incorporating the basic logic of the Stroop Color and Word test, an auditory animal word and sound test can be created producing an analogous interference response. Figure 4 illustrates that as hypothesized, people repeated a list of words (animal names) with a shorter reaction time than they identified the animal name when presented with the characteristic animal sound. Subjects also performed as expected on the word-sound combined stimulus task. Identifying an animal, based on its sound, in an incongruent word-sound pairing produced the slowest response times. Also as predicted, when a group of subjects was asked to identify the word in the word-sound pairing, they responded faster than the group that was asked to make a response based on the sound (see Figure 4). When asked to identify the spoken word and to ignore the animal's sound, subjects responded at a rate similar to that for identifying the word in the absence of the animal sound ($\bar{x}$=.5880 sec to $\bar{x}$ =.6555 sec). Subjects were able to ignore the animal's sound and repeat the words at a rate not different from the word identification condition. This result can be compared to what Stroop found in 1935. In that study when the subjects were asked to read the words printed in the color-word condition and to ignore the ink color, subjects performed the same as when reading the words in black ink (Stroop, 1935).

To investigate the comparison of the auditory and visual paradigm further the current investigation compared the results of the Animal Word and Sound test to a version of the Stroop test given to all subjects. Although the conventional findings of that comparison initially showed that the two tests, the SCWT and the AWST, were not significantly different, the analysis of simple effects did detect a difference between the

two tests. This similar interference pattern deserves further investigation. It is possible

that the difference in the response times of the AWST to the SCWT may be attributed to

the difference in auditory to visual processing, the input channel, and not to interference.

Animal Word-Sounds vs. Color-Words

Golden's (1978) standardized test was the version used in the current

investigation. Golden's research on replicating and establishing norms provides the

information needed to compare the AWST with other researchers' findings (Golden,

1978). If the time given for the completion of a test is divided by the number of items

completed by the subject, it is possible to compare the Animal-Word test graphically to

the Color-Word test.

Comparisons of the AWST to the results of Stroop's (1935) study, Jensen's (1965)

replication and Golden's (1978) scores show a similar trend among the three conditions

(see Figure 6). This pattern of results suggests that there may be a similar proportional

shift between each comparative condition of the SCWT, as well as the AWST. That

similarity is consistent with the findings of Stroop, Jensen and Golden (Golden 1978).

Interestingly, there is an increase in processing time of subjects on the AWST in the first

two conditions compared to the SCWT. It takes longer to repeat words and sounds then

to read words and colors. Although this difference in the current investigation was not

statistically significant, such a trend may be attributable to a difference between visual

and auditory processing. This shift indicates an area in need of additional research.

The results of researchers such as Wheeler (1977) have shown that when the

speed of the responses is emphasized over accuracy, the interference effect is increased.

Therefore, if an auditory task operates on the same principal, by manipulating the amount

Figure 6. A Comparison of the AWST to Past Stroop Research.
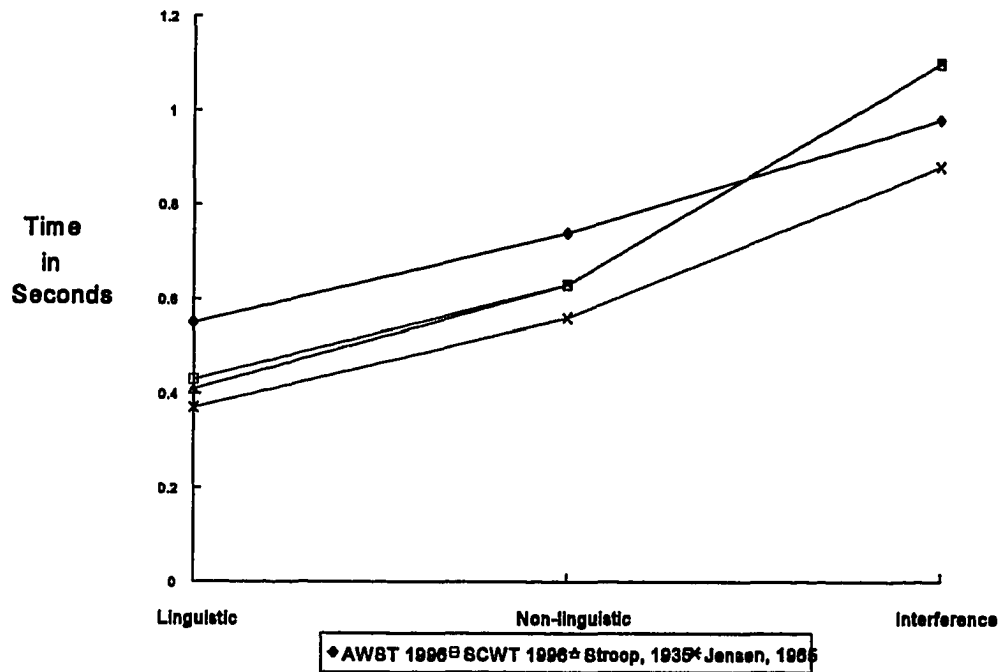
	Linguistic	Non-Linguistic	Interference
AWST 1996	$\bar{X} = 0.54$	$\bar{X} = 0.74$	$\bar{X} = 0.97$
SCWT 1996	$\bar{X} = 0.43$	$\bar{X} = 0.63$	$\bar{X} = 1.10$
Stroop, 1935	$\bar{X} = 0.41$	$\bar{X} = 0.63$	$\bar{X} = 1.10$
Jensen, 1965	$\bar{X} = 0.37$	$\bar{X} = 0.56$	$\bar{X} = 0.88$

of response time allotted (increasing or decreasing), the interference effect could possibly be manipulated. A shorter break between stimulus items could promote a quicker response, possibly decreasing accuracy and increasing the interference.

AWST vs. Audio Stroops

The difficulty in designing an auditory parallel to the SCWT has led many researchers to include stimuli labeled congruent, non-congruent, neutral, pseudo-congruent and pseudo-incongruent (Green and Barber, 1981; Hamers and Lambert, 1971; Cohen and Martin, 1975). This creates some limitations to comparisons that can be made to a test that is based on Muller and Schurman's Law of Associative Inhibition (Kline 1921). To make an appropriate comparison, an initial association, the related associative stimuli, and a new, combined associated element are needed.

While it is difficult to compare the first two conditions of the AWST to different combinations of unrelated stimuli as a pseudo-congruent or congruent item, it is possible to look at the response times of the interference conditions across all auditory paradigms.

Table 6 illustrates that the response time for a conflicting-stimulus type task produces a mean response time approaching one second. However, a measurement of interference is not meaningful without a comparison to responses to its component parts presented separately. By including the other conditions in auditory tasks, the following graphical comparison presented in figure seven can be drawn.

Table 6

Table Listing Mean Interference Response Times

Test	Interference TASK	Response Time
Parker (1995)	Word-Sound	0.97
Morgan & Brandt(1989) (pitch)	High-Low	0.96
Morgan & Brandt(1989) (loudness)	High-Low	0.77
Green & Barber (1981)	Man-Girl	0.47
Cohen & Martin (1975) (left ear)	High-Low	0.79
Cohen & Martin (1975) (left ear)	High-Low	0.90
Hamers & Lambert(1971)	High-Low	1.18

Among the audio tasks (see Figure 7), the results most similar to the AWST are

the High\Low tone pairings of Hamers and Lambert (1972) and Cohen and Martin (1975).

The similarity and the differences can be attributed to the experimenters' application of

Stroop's paradigm. In Hamers and Lambert's (1972) design, the subjects were asked to

respond to spoken words in congruent (the word high said in a high tone, low\low tone),

neutral (a tone played in high or low sound), and stimulus incongruent (the word high in a

low tone, low in high) conditions. This task was mixed with two bilingual conditions

(English and French) and two response types (verbal and manual). The verbal, English

responses were similar to that of the AWST (see Figure 7). The difference between

congruent and interference groups indicates only a slightly weaker interference effect.

This pattern of differences may be attributable to the existence of the congruent condition

as well as the dichotic response choice.

In a comparison to Cohen and Martin's (1975) task to the AWST, a relatively

weaker interference effect is observed. Cohen and Martin's study examined response

times to right and left ear stimuli. The stimuli were presented in congruent ("high" said in

a high tone, "low"\low), neutral (defined here as an unrelated word spoken in a high or

low tone), a tone condition (identifying high and low tones), and incongruent (high\low,

low\high) conditions. Figure 7 indicates approximately equal performance by the

subjects when asked to respond to pure tones as when they responded to the interference

condition. A similar effect is also found in Morgan and Brandt's (1989) study in both the

pitch and loudness conditions (see Figure 7). In their experiment congruent conditions

were again represented as "high" said in a high tone, "low" in low, and incongruent as

1.2
1
0.8
0.6
0.4
0.2
0

Words Sounds Word Sounds Congruent Neutral Incongruent Congruent Neutral Tone Incongruent Congruent Pseudo-Congruent Pseudo-Incongruent Incongruent

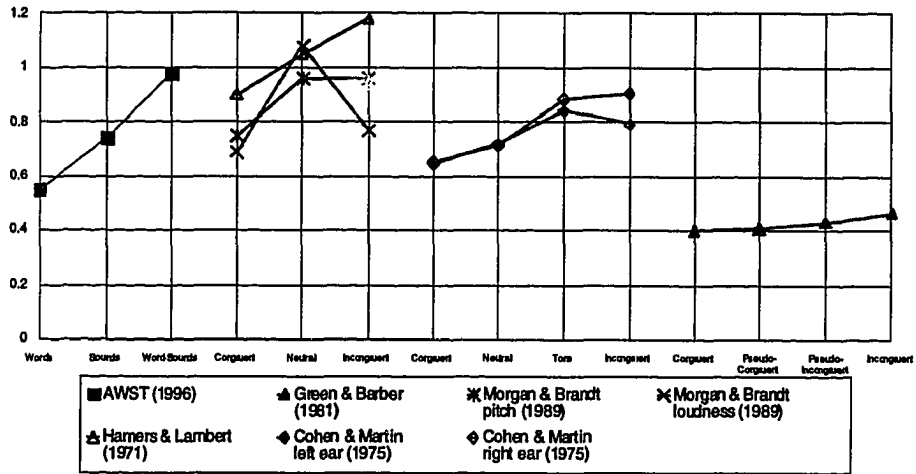| ■ AWST (1996) | ▲ Green & Barber (1981) | ✗ Morgan & Brandt pitch (1989) | ✗ Morgan & Brandt loudness (1989) |
| ▲ Hamers & Lambert (1971) | ◆ Cohen & Martin left ear (1975) | ◇ Cohen & Martin right ear (1975) | |

Figure 7. A Comparison of the Animal Word and Sound Test to Audio Stroops.

"high" in low, "low" in high tone. Of interest is the action of their neutral group. "Neutral" was the stimulus presented in a "normal" tone, neither high nor low. The interesting effect of this neutral group is that it shows a response latency greater than that of the interference condition. This brings to question whether the difference is the result of cognitive interference or just a confusion of the stimuli. There is a difference to be noted here between confusing two similar stimuli and creating interference of competing responses.

In Green and Barber's (1981) experiment they did find a significant effect, but comparing the differences between their groups and that of other audio tests, there is only a slight change. The relatively weaker interference effects may illustrate the importance of a strong word to task association.

The pitch of a person's voice is a perception, not necessarily an association with gender. Therefore, a test based on an individual's perception of pitch quality and gender traits may not create competition between two possible responses, but confusion to the identification of the correct items. In comparison to the SCWT, a colored block of red produces a distinct visual experience, possessing its own qualities rather than a printed word that represents that color. They are associated with each other, but one is not a variation of the other. Similarly, a spoken animal name, and the sound an animal makes, are distinctly different concepts as well as different stimuli. A test based on a person's perception of sounds will produce an effect, but is that task comparable to the SCWT? However, a test task with a strong linguistic to non-linguistic association will produce a measurable interference effect that is comparable to the Stroop.

Theoretical Interpretations

The results of the current investigation indicate that the auditory interference process may operate in a similar fashion to the interference responsible for the Stroop effect. The similarity of effects in both auditory and visual tests implies that the interference occurs at some point in the output channel. The input channel does not appear to be as important as is the content of the test task.

These results are similar to those of Stroops' 1935 study, in that the response times for a person to verbalize associated stimuli increases with the introduction of a new association. A person can respond most rapidly to spoken words, and a greater amount of time is required to respond to naming animal sounds. This response is further slowed by the introduction of a combined stimulus, the identification of animal sounds in a word-sound task. As Stroop attributed the interference to be the result of word, color and color-word associations, it can be interpreted that the increase in subjects' response times on the AWST can be attributed to the interference created by word, sound and word-sound associations. The previously learned skill of listening to spoken words interferes with the ability to name the incongruent word-sound pairing. We have learned to automatically filter out other sounds as background "noise" and focus our attention to that of the spoken words. Words were repeated more rapidly than sounds were named, therefore, it is now possible to argue that the Relative Speed of Processing theory as described by MacLeod (1991) can be applied to the AWST. Since the words were repeated faster than the sound could be named, the speed difference may have caused competition between the two potential responses. The increased time-delay in the dual-presentation condition presumably indicates the interference.

The Relative Speed of Processing theory as described by MacLeod (1991), could also be modified to explain an auditory task by altering its theoretical assumptions to: (a) the parallel processing of two dimensions of a stimulus can occur at different speeds whether that channel began at a visual or an auditory input center; (b) both auditory and visual information moves through a limited capacity response channel, into which only one of the two potential responses can be admitted; (c) priming of the responses is possible from several sources, such as preceding trials or other response-set elements of auditory or visual tests. So there are either two mechanisms (visual and auditory) that operate similarly or the two channels converge and then compete for the output. To further investigate this issue the question becomes, "how do the results of the Animal Word and Sound test apply to automatic processing?"

To apply the theory of Automaticity, or "later selection," to the AWST it would be theorized that the processing time required by one dimension of the word-sound stimuli demands a greater amount of attention than the processing of the other. Therefore, identifying and naming an animal's sound requires more attention than hearing the concurrently presented word. According to MacLeod (1991), it is assumed that in the Stroop test imbalance occurs because people have extensive experience reading words, as opposed to naming ink colors. Likewise, in the animal-word task, people have extensive experience listening to, hearing, and recognizing the meaning of spoken words, as opposed to identifying the actual sound stimuli that the word represents. Just as people are automatized to read words presented, they may automatically "tune into" and listen to words spoken.

When the perceptual conflict theory is applied to the AWST, it could be theorized that the semantic relatedness of the animal sounds interacts with the disruptive effects of the spoken distractor. The result of the encoding of the linguistic animal name creates interference in the processing of the non-linguistic animal sound. That effect is illustrated by the increase in the response time of the subjects on the word-sound condition.

CONCLUSIONS

The Law of Associative Inhibition as quoted by Kline in 1921 provides a viable model for creating cognitive interference. As this experiment has shown, by following the paradigm set by Muller and Schuman it is possible to create an auditory test task that produces results quite similar to the visual Stroop Color and Word test. Interference is created by combining two types of auditory stimuli into a new, novel test task. This auditory interference effect is comparable to that seen in the SCWT.

Stroop found in 1935 that effect was created by conflict that exists between pre-learned associations of linguistic (word) and non-linguistic (color) origins. The current investigation has shown that an auditory interference effect exists similarly between pre-learned associations of linguistic (word\names) and non-linguistic (sound) origins.

The purpose of this study was to demonstrate more than just an auditory interference effect. The basic phenomenon has already been reported by previous researchers. The purpose was to develop an auditory task that could be used to examine similar paradigms as the Stroop, when a visual test cannot be applied. The Stroop is a test that has been used in hundreds of studies because of its high reliability in identifying individual differences in personality and cognitive research, in psychopathology, and in the diagnosis of organic brain dysfunction (Golden 1978). These applications suggest possible directions for future research using the Animal Word and Sound test. There may also be a use of this test in application to people with visual impairment, including color

blindness. It would also be of interest to examine the scores of children with reading

disorders on this type of auditory test. Another interesting question relates to which area

of the brain is most critical in the Animal Word and Sound test, and whether that area is

also affected by the cognitive interference elicited by the Stroop task.

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APPENDIX A

HUMAN SUBJECTS APPROVAL FORM

PAWST

\# 626

HUMAN SUBJECTS COMMITTEE

DEPARTMENT OF PSYCHOLOGY

Research Review Notification Form

TO: Jason Poole / Duncan _____ DATE: 3-15-94

Principle Investigator

RE: The Annual-Word-and-Sound Test _____

Name of Project

Please be informed that your research proposal has been

reviewed by the committee and:

    Approved __✓_____

    Approved, contingent upon the following modifications:

    1. _____

    2. _____

    3. _____

    Refused _____

Do not hesitate to contact me should you desire further

clarification of the committee's decision.

_____

Chairperson, Committee for the Protection of Human Subjects

APPENDIX B

SUBJECT CONSENT FORM

OLD DOMINION UNIVERSITY
Department of Psychology

INFORMED CONSENT

Project Name: __PAWST 🐾 #626__

Investigator(s): __JASON L. PARKER__

Date: _____

This is to certify that I, _____ hereby agree
to participate as a volunteer in a scientific investigation as a part of
the educational and research program of Old Dominion University under the
supervision of __JASON PARKER__ .

The investigation and the nature of my participation have been described
and explained to me, and I understand the explanation.

However, I have been informed and do understand that some details of
the study may not have been explained at this time. This procedure is
sometimes necessary since advanced knowledge may affect the results.
I am aware that the exact nature of the study will be explained to me
during a debriefing at the end of the study.

I have been given an opportunity to ask questions, and all such questions
have been answered to my satisfaction.

I understand that I am free to withhold any answer to specific items or
questions in the questionnaires.

I understand that any data or answers to questions will remain confiden-
tial with regard to my identity.

I acknowledge that I was informed about any possible risks to my health
and well being that may be associated with my participation in this
research.

I further understand that I am free to withdraw my consent and terminate
my participation at any time, without penalty.
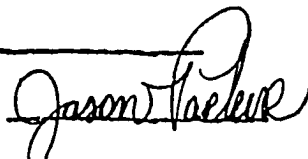
I have been informed that I have the right to contact the Psychology
Department Committee for the Protection of Human Subjects and/or the
University Committee should I wish to express any opinions regarding
the conduct of this study.

Date: _____   Signature: _____

Witnessed by: _Jason Parker_   Date of Birth: ___/___/_____

APPENDIX C

COLOR VISION SCREENING INVENTORY

COLOR VISION SCREENING INVENTORY*

Instructions

This questionnaire deals with a number of common perceptually related situations. For each question you should select the response which best describes you and your behaviors. You can select from among the following response alternatives:

Never (or almost never), Seldom, Occasionally, Frequently,
Always (or almost always)

Simply place a check next to the letter which corresponds to the first letter of your choice.

1. Do you have difficulty discriminating between yellow and orange? N☐ S☐ O☐ F☐ A☐
2. Do you have difficulty discriminating between yellow and green? N☐ S☐ O☐ F☐ A☐
3. Do you have difficulty discriminating between gray and blue-green? N☐ S☐ O☐ F☐ A☐
4. Do you have difficulty discriminating between red and brown? N☐ S☐ O☐ F☐ A☐
5. Do you have difficulty discriminating between green and brown? N☐ S☐ O☐ F☐ A☐
6. Do you have difficulty discriminating between pale green and pale red? N☐ S☐ O☐ F☐ A☐
7. Do you have difficulty discriminating between blue and purple? N☐ S☐ O☐ F☐ A☐
8. Do the color names that you use disagree with those that other people use? N☐ S☐ O☐ F☐ A☐
9. Are the colors of traffic lights difficult to distinguish? N☐ S☐ O☐ F☐ A☐
10. Do you tend to confuse colors? N☐ S☐ O☐ F☐ A☐

Scoring Instructions

Responses are scored 1 for *Never*, 2 for *Seldom*, 3 for *Occasionally*, 4 for *Frequently*, and 5 for *Always*. The total score is simply the sum of the 10 responses. Diagnostic cutoff points may be selected from Table 2. (In previous testing, these questions were distributed as part of an inventory containing other visual questions.)

*The Color Vision Screening Inventory is copyrighted by SC Psychological Enterprises Ltd , and reprinted by permission. It may be reproduced for research purposes only. We would appreciate receipt of copies of any data collected using this instrument as we are trying to establish population norms to assist researchers in interpretation of data collected with the CSI.

Table 2
Percentage of Cross-Validation Sample (N=596) Correctly
Classified Against Screening With Pseudo-Isochromatic Plates

Color Scale Total	Normals (Less than)	Color Weak (Greater than or equal to)	Total Sample
11	21.6	90.5	24.0
12	40.9	90.5*	42.6
13	56.5	90.5†	57.7
14	67.3	85.7†	68.0
15	77.4	85.7†	77.7
16	83.7	81.0†	83.6
17	89.0	81.0†	88.8
18	92.7	71.4†	91.9
19	94.8	61.9†	93.6
20	96.0	61.9†	94.8
21	97.4	61.9†	96.1
22	98.4	61.9†	97.1
23	99.0	61.9†	97.7
24	99.3	52.4†	97.7
25	99.7	47.6†	97.8

Note—Individuals with scores less than the Color Scale Total are classified as "normal" and those with scores greater than or equal to the Color Scale Total are classified as "color weak." Chi-square significant at *p < .05 and †p < .001.

APPENDIX D

INSTRUCTIONS TO ANIMAL WORD AND SOUND TEST

For Word, Condition One

"This is a test of how fast you can repeat the words said to you. After I say begin you will hear a series of words, you are to repeat the words as quickly as possible.

Remember, you are to repeat the words as quickly as you can. If you make a mistake, correct your error and continue without stopping. Are there any questions? Ready?...Then begin."

For Sound, Condition Two

"This is a test of how fast you can name the animals whose sound you will hear. For example you may hear a Bird (SOUND), Dog (SOUND), or a cat (SOUND).

Remember, you are to name the animal as quickly as you can. Are there any questions? Ready?...Then begin."

For Word-Sound, Condition Three

"This test is like the one you just finished. You will hear an animal's sound and an animal's word name simultaneously. I want you to repeat the name of the animals sound, ignoring the spoken word.

For example if you heard (WORD-SOUND) the correct response would be _____. Now try this one (WORD-SOUND). The correct response for this one would be _____.

Remember, you are to identify the sound as quickly as you can. Are there any questions? Ready?...Then begin."

For Word-Sound, Condition Three-Alternate form

"This test is like the one you just finished. You will hear an animal's sound and an animal's word name simultaneously. I want you to repeat the spoken word, ignoring the animal's sound.

For example if you heard (WORD-SOUND)...the correct response would be_____. Now try this one...(WORD-SOUND),...The correct response for this one would be _____.

Remember, you are to identify the word as quickly as you can. Are there any questions? Ready?...Then begin."

APPENDIX E

ANIMAL WORD AND SOUND TEST STIMULI

.

(Words)

cat	dog	cat	bird	bird
dog	cat	dog	cat	dog
bird	bird	bird	dog	cat
cat	cat	cat	bird	bird
dog	bird	bird	dog	dog
bird	dog	dog	cat	cat

(Sounds)

cat	cat	bird	cat	cat
bird	bird	dog	dog	bird
dog	dog	cat	bird	dog
bird	bird	bird	dog	cat
cat	cat	cat	cat	bird
dog	dog	dog	bird	dog

(Words/Sounds)

cat/dog	cat/bird	bird/dog	bird/dog	bird/dog
dog/cat	bird/cat	dog/cat	dog/cat	cat/bird
cat/bird	cat/dog	dog/bird	dog/bird	bird/cat
dog/bird	bird/dog	cat/dog	bird/cat	dog/bird
bird/dog	dog/cat	cat/bird	cat/dog	dog/cat
bird/cat	dog/bird	bird/cat	cat/bird	cat/dog

APPENDIX F

INSTRUCTIONS TO STROOP COLOR AND WORD TEST

For Word reading, Condition One

"This is a test of how fast you can read the words on this page. After I say "Begin," you are to read down the columns starting with the first one until you complete it and then continue without stopping down the remaining columns in order. If you finish all the columns before I say stop, then return to the first column and begin again. Are there any questions? Ready?...Then begin"

For the Color reading, Condition Two

"This is a test of how fast you can name the colors on this page. You will complete this page just as you did the previous page, starting with this first column. Remember to name the colors out loud as quickly as you can. Are there any questions? Ready?...Then begin"

For Color-Word reading, Condition Three

This page is like the page you just finished. I want you to name the color of the ink the words are printed in, ignoring the word that is printed in each item. For example, this is the first item: what would you say? Now what would you say for this item? Good. You will do this page just like the others, starting

with the first column and then going on to as many columns as you can. Remember if you make a mistake, just correct it and go on. Are there any questions? Ready?...Then begin."

APPENDIX G

STROOP COLOR AND WORD TEST

RED	BLUE	GREEN	RED	BLUE
GREEN	GREEN	RED	BLUE	GREEN
BLUE	RED	BLUE	GREEN	RED
GREEN	BLUE	RED	RED	BLUE
RED	RED	GREEN	BLUE	GREEN
BLUE	GREEN	BLUE	GREEN	RED
RED	BLUE	GREEN	BLUE	GREEN
BLUE	GREEN	RED	GREEN	RED
GREEN	RED	BLUE	RED	BLUE
BLUE	GREEN	GREEN	BLUE	GREEN
GREEN	RED	BLUE	RED	RED
RED	BLUE	RED	GREEN	BLUE
GREEN	RED	BLUE	RED	GREEN
BLUE	BLUE	RED	GREEN	RED
RED	GREEN	GREEN	BLUE	BLUE
BLUE	BLUE	RED	GREEN	RED
RED	GREEN	BLUE	RED	GREEN
GREEN	RED	GREEN	BLUE	BLUE
RED	BLUE	RED	GREEN	RED
GREEN	RED	GREEN	BLUE	GREEN

XXXX   XXXX   XXXX   XXXX   XXXX

XXXX   XXXX   XXXX   XXXX   XXXX

XXXX   XXXX   XXXX   XXXX   XXXX

XXXX   XXXX   XXXX   XXXX   XXXX

XXXX   XXXX   XXXX   XXXX   XXXX

XXXX   XXXX   XXXX   XXXX   XXXX

XXXX   XXXX   XXXX   XXXX   XXXX

XXXX   XXXX   XXXX   XXXX   XXXX

XXXX   XXXX   XXXX   XXXX   XXXX

XXXX   XXXX   XXXX   XXXX   XXXX

XXXX   XXXX   XXXX   XXXX   XXXX

XXXX   XXXX   XXXX   XXXX   XXXX

XXXX   XXXX   XXXX   XXXX   XXXX

XXXX   XXXX   XXXX   XXXX   XXXX

XXXX   XXXX   XXXX   XXXX   XXXX

XXXX   XXXX   XXXX   XXXX   XXXX

XXXX   XXXX   XXXX   XXXX   XXXX

XXXX   XXXX   XXXX   XXXX   XXXX

XXXX   XXXX   XXXX   XXXX   XXXX

RED	BLUE	GREEN	RED	BLUE
GREEN	GREEN	RED	BLUE	GREEN
BLUE	RED	BLUE	GREEN	RED
GREEN	BLUE	RED	RED	BLUE
RED	RED	GREEN	BLUE	GREEN
BLUE	GREEN	BLUE	GREEN	RED
RED	BLUE	GREEN	BLUE	GREEN
BLUE	GREEN	RED	GREEN	RED
GREEN	RED	BLUE	RED	BLUE
BLUE	GREEN	GREEN	BLUE	GREEN
GREEN	RED	BLUE	RED	RED
RED	BLUE	RED	GREEN	BLUE
GREEN	RED	BLUE	RED	GREEN
BLUE	BLUE	RED	GREEN	RED
RED	GREEN	GREEN	BLUE	BLUE
BLUE	BLUE	RED	GREEN	RED
RED	GREEN	BLUE	RED	GREEN
GREEN	RED	GREEN	BLUE	BLUE
RED	BLUE	RED	GREEN	RED
GREEN	RED	GREEN	BLUE	GREEN

VITA

Jason L. Parker was born on September 12, 1965 in Virginia Beach, Virginia. He completed his Bachelors of Science in Psychology at Old Dominion University, Norfolk, Virginia in 1989. He was accepted into Old Dominion University's Graduate program in 1990, and he completed his Master of Science in Psychology in 1996. While attending Old Dominion University he was a member of Psi Chi, Psychology Honor Society, Golden Key, National Honor Society and served as President of Alpha Phi Omega, ABΩ Chapter, a National Co-ed Service Fraternity. Jason Parker currently works as a Hypnotherapist in Virginia Beach, Virginia. He is a member of the American Board of Hypnotherapy and the National Guild of Hypnotists.

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