Stroop effect introduction and theories essay sample

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When the words ‘ red, green, yellow and blue’ printed in coloured inks but in incongruent combinations of colour and word e. g. the word ‘ red’ printed in colour yellow, the word yellow in the colour blue and so on and the Ss are required to name the colours as quickly as they can, ignoring the words, it is not easy to do so. Invariably, the colours are hard to name than when they are shown in simple strips uncomplicated by the words. Typically volume of voice goes up; reading falters; now and then the words break through abortively and there are embarrassed giggles. These and other signs of strain and effort are common. This phenomenon was first noticed by Janesch and was first reported in this century by John Ridley Stroop (1935).

In 1955, Stroop published his landmark article on attention and interference. The task given came to be known as the Stroop Task and is seen as tapping in to the primitive operations of cognition, offering clues to the fundamental process of attention. He found that people required an average of 110 seconds to name the ink colour of 100 words that were incongruent colour names, as against 63. 3 seconds to name the ink colour of 100 solid colour squares.

REVIEW OF LITERATURE

The roots of Stroop’s research are evident 50 yrs earlier in the work of James McKeen Catell (1886). He reported that objects and colours took longer to name them than corresponding words to read. This is because, in the case of words and letters, the association between the idea and name has taken place so often that the process has become automatic, whereas in the case of colours and pictures, we must by voluntary effort choose the name.

Catell’s studies were replicated by Hollingsworth, Brown and Rigen. Hollingworth (1912, 1915, and 1923) suggested that word reading required only articulation, but that colour naming demanded articulation plus association. Brown (1915) and Ligon (1932) maintained that both tasks involved two processes but with different association element for each test. Garret and Lemmon (1924) held that colour naming was longer because of an interference factor. Peterson, Lanier and Walker (1925) suggested that many responses might be conditioned to a single colour, but only one response was conditioned to a single word.

It was Stroop who thought of combining words and colours (1935). Stroop was concerned with how best to explain interference. Stroop had been engaged in studies of colour naming versus word reading and hit upon the idea of a compound stimulus where the word was incongruent with ink colour. His two main questions were – what effect each dimension of the compound stimulus would have on trying to name the other dimension and what effect practice would have on the observed interference. Stroop himself studied it with a series of three experiments:

In the first experiment, he examined the effect of incompatible ink colour on reading words aloud. In the second experiment, the task was switched to naming the colours aloud. He observed that the Ss averaged 47 seconds to name the ink colours of incongruent words than solid colour squares. In the third experiment, he observed the effect of practice on colour naming tasks and found that it reduced time significantly.

Ever since, there has been a lot of research on the Stroop Effect, These research studies can be broadly classified into five sections –

1. Variations of the Stroop procedure.
2. Manipulation of information on critical trials.
3. Experiment-wide manipulations of information.
4. Response-related manipulations.
5. Individual differences.

1. Variations of the Stroop procedure:

The standard Stroop colour- word test involves naming the colours of incompatible words and colour patches. Interference is expressed as the difference between the times on these two types of tasks.

Many investigators have altered this basic procedure. Rather than naming or reading the stimuli aloud, The Ss are asked to sort the stimuli into categories (Tecce and Happ). Instead of presenting incongruent colour-word units, the word is placed above or below the colour patches.

Dyer used picture-word interference task. [Congruent or incongruent embedded words inside line drawings] Embossing color words in white letters on colored plastic tape and Ss had to name the tape color.

Hamers (1973) created auditory Stroop task. [say HIGH to the ‘ low’ pitch tone and vice versa]

Few studies have used naturally coloured objects.

Hue variations: chromatic (red, green, blue shades) Vs achromatic color-word units

Cramer and Arochova developed an object-based test for use with children.

Response modality: oral Vs manual: Keele (1972) argued that when Ss pressed buttons to indicate their responses (rather than speaking them), only color words interfered; non-color words and scrambled color words did not differ from control. Keele's use of manual responses known to decrease interference overall.

Trial Sequence: Interference increases when to be ignored word on one trial turns out to be the to be named color on next trial (e. g: green in red ink precedes blue in green ink. These are known as sequential effects in Stroop task.

2. Manipulations of information on critical tasks: These studies include manipulations pertaining to individual trials, the overall approach to the whole task, the response demands or the qualities of the individual subjects.

Few studies have examined hues of the to-be-named inks (Sichel and Chandler, Dyer, 1971). It was observed that the Ss named achromatic patches slightly faster than chromatic patches.

Variations of word context: Klien's Study:

There are studies on semantic variation. Klein (1964) has conducted a classic study on this. He used the following conditions in this experiment- the first condition is ' colours-alone', second, ' incongruent colour-word units',

third, ‘ colour related words’ and fourth, ‘ nonsense syllables’. He found that more meaningful the irrelevant word, the more interference it caused.

Klein has tried to vary the verbal text in which the colours are embedded. In condition A, the items were nonsense syllables (bjh, eygjc, bhdr), In condition B, they were rare English words (abjure),

In condition C, they were common English words.
In condition D, they were colour related words (grass, fire, sky) In condition E, they were different words of the same response class (tan, violet, aqua) In condition F, it was the standard condition (words same as the colour names but presented in incongruent combinations of colour and word).

The results of the experiment were as follows: in all conditions, reading time was significantly slower on the conflict pages than on colour alone. As the words became more meaningful and more closely related to colours, the interference increment time (reading time of conflict page minus reading time for colour alone) became increasingly larger.

Clearly, different attributes of the words differentially affected the colour-naming response. Not only colour words but also highly familiar words had an interfering effect, but in a lesser degree. Even the arbitrary letter-combinations of the non-sense syllables created a significant rise in interference over the naming of colour in asterisks. The impeding effect of the words upon the relevant motor-response was governed by the relative meaningfulness of the words, and their relation, through the linguistic motor-component, to the colour naming response. The verbal text affects the ease of colour naming. When two motor responses are competing for one

response channel, it is possible that reading delay is produced by an effort to ‘ hold back’ one of them. To make the appropriate motor-response, S has to expend effort momentarily to restrain the near-threshold irrelevant response. This effort may be reflected in the slowed reading time.

Some studies are related to the Stroop facilitation. If the wrong or incongruent word interferes with the colour-naming, then the congruent word ought to speed performance. For e. g. the word red in red ink. It was found that congruent colour-word unit produces less interference than incongruent colour-word unit.

Raz, Kirsch, Pollard and Nitkin-Kaner (2006) demonstrated that the suggestion to construe words as meaningless symbols (characters of an unknown foreign language) reduces, or even eliminates, standard Stroop interference in highly suggestible individuals. In other words, researchers concluded that, suggestion de-automatize word reading. According to Raz, suggestion may instigate lowered visual system activation by reducing attention either to specific visual stimuli (e. g., words) or to the actual input stream (e. g. dampening down all visual stimuli)

Augustinova and Ferrand (2012), challenge the claim of Raz et al that suggestion de-automize word reading. In their studies, highly suggestible individuals completed both standard (standard incongruent trials) (the word blue displayed in green) and semantically based Stroop tasks (presentation of words that were simply associated with an incongruent colour), (the word “ sky” displayed in green) with or without as suggestion to construe the words as meaningless symbols. They found significant semantically based

stroop effect, which led to conclusion that word reading cannot be de-autmatized. Semantic activation cannot happen without reading. That means, suggestion does not de-automatize or prevent reading, but rather simply reduces non-semantic task-relevant response competition.

3. Experiment-wide manipulations of information: These studies include the probability of various trial types, stimulus set size, trial sequence and reverse stroop effect.

Psychologists like Dalrymple-Alford found that colour naming reduced as more congruent trials were added. Some studies have demonstrated the ‘ Reverse Stroop Effect’ i. e. normally a word interferes with the naming the colour but a situation is created wherein the colour interferes with reading the word. It was first reported by Stroop himself. This effect occurs only after considerable training and is quite transient. This occurs mainly due to practice and training.

Many studies have proved that the Stroop interference is a direct consequence of differential practice. Thus variation in practice should have a direct impact on the task. Intuitively, extended practice with the Stroop task should lead to reduced interference as subjects develop a strategy for coping more successively with the task. Majority of the studies have observed this result.

4. Response-related manipulations: Some psychologists have examined the response modalities in the Stroop task. E. g. vocal response output v/s manual response output (e. g. a key press). The general conclusion of all

these studies is that interference is reduced when response modality is switched from oral to manual.

5. Individual Differences: Many researchers have examined the relation between Stroop interference and some individual differences parameters.

Some studies have tried to explore ...

Gender differences in the Stroop task (Studies by Golden, Sladekova and Daniel, 1981, Naish, 1980). The general conclusion of these studies is that there is no difference between men and women in the Stroop task.

Age difference- A life span study was conducted by Comalli where the sample consisted of Ss from 7 yrs to 80 yrs of age. They found the greatest interference in young children; interference declined into adulthood and then increased again with advanced age.

Hemispheric Differences- Studies by Dyer, McCown, Schmidt and Davis have concluded that the left hemisphere shows more interference than the right. Language Differences- In this field, studies were conducted on bilinguals. In studies conducted by Dyer and Lambert, the procedure involved naming the ink colour in one language but the words were written in another language. However, there have been no conclusive findings on these studies.

THEORETICAL ACCOUNTS OF THE STROOP EFFECT

Relative speed of processing and automaticity view are two prevalent and preeminent views in the literature and they are conceptually close to each other.

1. Relative Speed of Processing (Stroop and Klein)

Words are read faster than colours are named (Cattell, 1886; Fraisse, 1969).

As Stroop (1935) explains his data, the associations that have been formed between the word stimuli and the reading response are evidently more effective than those that have been formed between the colour stimuli and the naming response. Since these associations are product of training, and since the difference in their strength corresponds roughly to the difference in training in reading words and naming colours, it seems reasonable to conclude that the difference in speed in reading names of colours and in naming colours may be satisfactorily accounted by the difference in training in the two activities.

This speed difference is seen as particularly critical when two potential responses (e. g. one from a word and one from an ink colour) compete to be the response actually produced. The time cost of this competition is ‘ interference’.

The ‘ relative speed of processing’ hypothesis contains certain key assumptions-

First, it is assumed that there is parallel processing of the two dimensions of the stimulus at differential speed. Second, there is a ‘ limited- capacity response channel’ wherein only one of the two potential responses can be

admitted at a time; the priority is determined by speed. Third, there is a potential for priming of possible responses from several sources including preceding trials and other response set elements.

Klein (1964) further suggested that the ability of the word to produce arousal is called the ‘ Attensive power’ of the word. Greater the attensive power, more the interference created by the word. According to Klein, attensive power, in the context of a colour naming task is a function of the meaningfulness of words. In the Stroop task the Ss are not allowed to release the word response, they have to name the colour instead. This creates conflict and leads to ‘ Motor Antagonism’ (arousal of a competing motor response). This makes it necessary for the S to seek additional stimulation from the region for relevant perceptual information. This means that the colour naming threshold is assumed to be constant and reaching this threshold has been retarded by the arousal of a competing motor response. To reach it, the subject stimulates himself again with the colour-word combination. Increase in the reading time is indicative of the time required by the S to stimulate himself again. Klein however has not specified the mechanism of restimulation.

Effects of Response Release: Klien (1964) experiment:

In the second experiment by Klein (1964) termed as “ effects of response release”, the hypothesis was – “ if colour naming delay is indeed produced by the necessity of holding back a competing response, it should disappear when the Ss are allowed to say aloud both word and colour name.” To test the hypothesis, the standard colour-word conflict page containing

100 colour-word units was used with two variations of instructions. In condition I, Ss first read aloud the word and then named the colour of the colour-word unit. Ss in condition II read aloud both the words in reverse order of Condition I – i. e., they first named the colour and then read the word. If holding back the word contributes to interference, the interference in colour naming should reduce only when the word is allowed to come out first i. e., in condition I. The interference would still operate in condition II, when Ss were permitted to release the word, only after naming the colour. It was found that the Double Response Word-then-Colour (condition I) was the easier task. The relative frequencies of errors in the Standard and Double Response tasks also showed that colour naming was easier in condition I (word-then-colour).

2. Automaticity of reading (rooted in Cattell’s work)

The basic idea is that, processing of one dimension requires much more attention than does the processing of the other dimension. Thus, naming the ink colour draws more heavy attentional resources than does reading the irrelevant words. Moreover, reading the word is seen as obligatory, whereas naming the colour is not. Words are read automatically and colours require more attention to be named. More automatic processing interferes with the less automatic processing and vice versa.

This description is based on the theories of La Berge and Samends (1974), Posner and Snyder (1975) and many others. All of these investigations show Automaticity as a gradient that develops with learning. Thus, word reading was very automatic; the colour naming was much less automatic. Most

automatic processing could then interfere with less automatic processing, but not vice versa. The Stroop Effect is an interesting case especially because the two dimensions differ so much in how automatically they are processed.

3. Perceptual Encoding (Hock and Egeth, 1970)

Perceptual Encoding hypothesis emphasizes that conflict occurs at ‘ early selection’. The basic idea is that perceptual encoding of ink colour information is slowed by incompatible information from a colour word. Colour words are recognized earlier and thereby more likely to distract the subject from encoding ink colour. This view has been criticized by Dyer (1973) as relying on a questionable assumption about the rates of processing word versus colour information.

4. Logan’s Model (Logan, 1980)

According to Logan, stroop Effect is decision process gathering evidence. Evidence accumulates over time until a response threshold is reached. Evidence from each dimension is processed at a rate governed by its weight. These weights determine each dimensions contribution to the decision. Total evidence at threshold is the sum of all evidence from all the dimensions. If the evidence from all the other dimensions is consistent with the desired dimension, the threshold and the processing for the desired dimension is reduced. However, if irrelevant dimensions provide evidence conflicting with the desired dimension, response speed will be slowed.

5. Parallel Distributed Processing Approach (McClelland and Rumelhart, 1986)

It is a combination of automaticity, relative speed of processing and Logan's model. According to this model, processing occurs in a system through activation moving along pathways of different strengths. It proposes that cognitive processes can be understood in terms of networks that link together millions of units. Processing is performed in a system comprised of interconnected modules and within each module there are continually operating elementary processing units responsible for accepting input from the some units and then providing output to the other units. Knowledge is represented as a pattern of activation over units which can change in time in continuous, non-linear manner. Processing occurs by speed activation along connections that exist within modules as well as between modules. For simplification, Cohen assumed that information flows in one direction i. e. from input to output.

When the model is instructed to perform a task, it selects a pathway that includes some or all of the units in one or more modules. The set of connections in this pathway, specifies its strength and the choice of pathway, therefore it determines both the speed and accuracy of processing. Individual units can be members of more than one pathway, allowing interactions between processes when their pathways intersect. Thus, if the two pathways are active simultaneously and produce conflicting activation at their intersection, interference results and if they produce coinciding activation, facilitation results. Such intersections can occurs anywhere in processing and there can be multiple intersections.

One of the features of this model is its incorporation of a clear role for attention. Attention tunes or modulates the operation of processing units in a pathway. However, attention accomplishes this tuning simply as another source of information would, it has no privileged status.

For example, there are two pathways- one for the ink colour and one for the word information – that share a response mechanism. Each pathway has a set of input units each of which connects to every intermediate unit. In turn, each intermediate unit connects to all output units. Processing begins with the input units and feeds upward to the response units, one of which will eventually acquire sufficient activation to exceed the threshold and produce a response. The only other element is the task-specific attentional units attached to the task-appropriate intermediate units and capable of tuning attention.

(Parallel distributed processing approach – when s is assigned the task of reading words and naming colorus, two pathways are activated. One pathway is of naming the colour in which the word is written and the second pathway involved was reading the word. Interference occurs when two pathways are activated simultaneously and compete for response and in the process affect the performance).

The present experiment aims at demonstrating the Stroop Effect by giving one subject scrambled colour-word units and the other incongruent colour-word units. In the latter condition, more conflict is generated. Hence, reading time and the number of errors increase.

Practical Applications of Stroop Effect

Stroop test it is a test of focus, distractibility, and impulsivity. There are circumstances encountered everyday that require the need to switch attention back and forth between two or more things. The need to focus or divide attention is largely determined by the demands of the tasks. Such as, driving a car while talking on a cell phone. The tasks which are automatic in nature require little or no attention while others need deliberate focus to accomplish them. Stroop effect is used by cognitive psychology to investigate the behind the scenes properties of the automatized task.

In the clinical setting this test is considered to measure selective attention, cognitive flexibility and processing speed and it is routinously used as a tool in the evaluation of executive functions. It can be used to assess various clinical conditions as an increased interference effect is found in disorders such as brain damage, dementias and other neurodegenerative diseases, attention-deficit hyperactivity disorder, or a variety of mental disorders such as schizophrenia, addictions and depression.

The Rationale of the Experiment

This experiment is based on Klein’s experiment. The rationale given by Klein for the Stroop Effect is the rationale of the present study. He suggested that the ability of the word to produce arousal is called the ‘ attensive power’ of the word. Greater the attensive power, more the interference created by the word. In the Stroop task the Ss are not allowed to release the word response, they have to name the colour instead. This creates conflict and leads to ‘ motor antagonism’ which makes it necessary for the S to seek additional stimulation from the region for relevant perceptual information. This means

that the colour naming threshold is assumed to be constant and reaching this threshold has been retarded by the arousal of a competing motor response. To reach it, the subject stimulates himself again with the colour-word combination. Increase in the reading time is indicative of the time required by the S to stimulate himself again.

Methodological Issues

1. The response set size (100) and the stimulus set size (10) was great. Care needs to be taken to reduce both response set size and stimulus set size. At times, confusion could be caused by the colours which are similar to each other.

2. The E had to note errors, observe subjects to note whether s/he resorts to any device while naming colours and had to time subject as well. This might have reduced accuracy and efficiency of the task.

3. Though the names of the colours are scrambled in Scrambled colour-word unit condition, many subjects may able to read the meaningful word out of the scrambled words (because they are simple, familiar colour names) and they will interfere with the colour naming just as meaningful words in Incongruent colour-word units.

4. There are two dependent variables in this experiment – one is time taken to complete the task and the other one is number of errors. In the context of this, the speed – accuracy trade off may be the methodological issue. It could happen that as subject speeds to complete the task of naming the colour, there is a possibility that the errors would increase in number. Or as

s/he takes time to slowly complete the task of naming the colour, the errors would decrease and efficiency would increase. When interference increment time and errors are both taken as dependent variables, the interference is more likely to be noted in the form of one of the variable, not both.

5. Practice effect – with practice and training the stroop effect can be lessened. Many studies have proved that the Stroop interference is a direct consequence of differential practice. Intuitively, extended practice with the Stroop task should lead to reduced interference as subjects develop a strategy for coping more successively with the task.