A PRELIMINARY INVESTIGATION INTO THE COGNITIVE ABILITIES OF THE PERSONS WITH STUTTERING USING SIMON AND STROOP TASKS

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ALL INDIA INSTITUTE OF SPEECH & HEARING,

MANSAGANGOTHRI, MYSORE-570006

MAY 2009.

To

The Lord Almighty,

My Beloved Parents,

My Brothers, Shoban Anna

&

Arun B. T

CERTIFICATE

This is to certify that this dissertation entitled ***"A Preliminary Investigation into the Cognitive Abilities of the persons with Stuttering using Simon and Stroop Tasks"*** is a bonafide work in part of fulfillment for the degree of Master of Science (Speech – Language Pathology) of the student Registration No: 07SLP002. This has been carried under the guidance of a faculty of this institute and has not been submitted earlier to any other university for the award of any diploma or degree.

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DECLARATION

This is to certify that this master's dissertation entitled "***A Preliminary Investigation into the Cognitive Abilities of the Persons with Stuttering using Simon and Stroop Tasks***" is the result of my own study and has not been submitted earlier to any other university for the award of any degree or diploma.

Mysore **Registration No: 07SLP002**

May, 2009

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"If any of you lacks wisdom, let him ask of God, who gives to all liberally and without reproach, and it will be given to him"

(James 1:5)

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CHAPTER – 1

INTRODUCTION

Speech is a mirror of the soul

- Publilius Syrus (~100 BC)

Communication is a process by which information is exchanged between individuals through a common system of symbols, signs or behavior. As far as behavior is concerned speech is a behavior which differentiates humans from the animal kingdom, through which we express our ideas needs, thoughts and emotions very effectively. Communication involves two major components: comprehension and expression of spoken words. Speech production is a very complex process which requires great amount of cognitive processes. In the early stage of human development through cognitive ability, a child acquires his/her basic skills for survival. Cognition also helps a child to acquire his speech and language ability without any delay or deviancy.

A child with a cognitive deficit due to congenital or acquired problems in early stages shows delay or deviant language development. Speech language processing has been investigated in many communication disorders. Speech language processing is nothing but a information processing which requires cognitive components like attention, memory, decision making, etc,.

Stuttering has been viewed as a puzzling disorder by the speech language pathologists and by many other professionals investigating it due to its unknown cause or complex nature. Over the past six to seven decades stuttering has been investigated for its cause, nature, therapeutic management by professionals from various disciplines which deal with cognition, speech-language, behavior, information processing, etc,. However, so far none of them could explain the underlying nature of stuttering.

It was the Greeks who made the first documentation on stuttering. Hippocrates (C. 460-377 BC), generally regarded as the father of traditional medicine, referred briefly in his work to "trauloi" which meant speech disorders including stuttering. Later Aristotle discussed stuttering unambiguously in his literature. He was of the opinion that stuttering is due to a weak tongue, too sluggish to keep up with the conception of the mind.

There seems to be so much of uncertainty when we speak of stuttering as speech language pathologist. There is very little consensus on what causes stuttering and what features constitute stuttering. Van Riper (1971) aptly describes our understanding about stuttering as six blind men describing an elephant by touching different parts of the body. However, there seems to be more agreement on what constitutes stuttering. The description of stuttering by Wingate (1964) is considered as an adequate characterization of stuttering for many purposes including research.

According to Wingate (1964) "stuttering is characterized by a disruption in the flow of speech that is characterized by involuntary, audible, or silent repetitions or prolongation of sounds and syllables. These disruptions occur frequently or they are noticeable in character, are not readily controlled, and are sometimes accompanied by unusual movements, of the speech mechanism or other body parts".

Considering the research on stuttering, enormous amount of investigations have been carried out to explain stuttering phenomenon.

Views on motoric and linguistic perspective:

One important contemporary view of stuttering posits that speech disfluencies arise from anomalous speech motor control or how the motor control system interacts with emotional, linguistic, cognitive and metabolic processes (Brown, Ingham, Ingham, Laird & Fox, 2005; Denny & Smith, 1997; Kent, 2000; Max, Guenther, Gracco, Ghosh & Wallace, 2004; Smith & Kelly, 1997; Zimmermann, 1980a). For example, Zimmermann (1980a) suggested that persons who stutter (PWS) move their speech articulators in ways that make the underlying motor control process susceptible to disruption from varying sources of input. This view predicts that, in addition to perceptible episodes of speech disfluency, PWS exhibit anomalies in speech motor output during their fluent speech.

While motoric aspects (e.g., speech motor control of articulation, phonation and respiration) of stuttering have received considerable attention in the past 20 years, developing lines of evidence suggest that linguistic variables such as phonology, semantics and syntax may contribute just as much, if not more so, to childhood stuttering. For example, stuttering has been found to be more common on low frequency word-initial phonemes (Wingate, 1988); infrequent, unfamiliar words (Hubbard & Prins, 1994); longer, syntactically more complex utterances (Bernstein-Ratner & Sih, 1987; Melnick & Conture, 2000; Yaruss, 1999); and sentence-initial and clause-initial words (Bernstein, 1981; Howell & Au-Yeung, 1995). More recently encoding processes (semantic, phonology and syntax) of PWS were investigated using speech reaction time measurement (SRT). Results showed unequivocal findings (Wijnen & Boers 1994; Melnick, Conture & Ohde, 2003).

Cognition and Stuttering

The findings and theory on cognition and stuttering give us an indication that the cause does not necessarily lie at the level of peripheral neural level, but might lie at a more central level. Cognition is central for any processing and planning (motor or speech). In order to understand the language processing, it will be useful to understand some basic processes of cognition that is information processing. Simon Effect and Stroop Effect are a couple of tasks evolved to study the cognitive processes involved in language processing.

The Simon Effect refers to the finding that reaction times are usually faster and more accurate when the stimulus occurs in the same relative location as the response, even if the stimulus location is irrelevant to the task (Simon 1960). Simon's original explanation for the effect was that there is an innate tendency to respond towards the source of stimulation.

“Stroop Effect” is named after J. Ridley Stroop who discovered this strange phenomenon in the 1930’s.The Stroop Task is a psychological test of mental (attention) vitality and flexibility. The task takes advantage of our ability to read words more quickly and automatically than we can name colors. If a word is printed or displayed in a color different from the color it actually names; for example, if the word "green" is written in blue ink, we will say the word "green" more readily than we can name the color in which it is displayed, which in this case is "blue”. The cognitive component involved in this task is attention that inhibits or stops one’s response in order to say or do something else. Further explanations of these two tasks are given in the next chapter. Only few studies used stroop task to investigate cognitive ability of PWS (Subramanian & Yairi 2006;

Caruso, Chodzko-Zajko, Bidinger & Sommers, 1994). But none of the studies have used Simon task to investigate the cognitive ability of PWS. The present study therefore aimed at investigating information processing in PWS using both Simon and Stroop tasks.

Aims of the study:

The aim of the present study is to investigate the information processing ability in PWS compared to Persons with No Stuttering (PWNS) using Simon and Stroop tasks by comparing the reaction time under the following conditions:

- Simon task in both 2-color and 4-color conditions
- Stroop task
- RT for combined tasks (Stroop & Simon)
- To compare the performance of both groups (PWS & PWNS)

Objectives: The specific objectives of the study are to compare the performance of PWS and PWNS on Simon and Stroop tasks:

- To see if there is spatial interference in PWS compared to PWNS using Simon effect.
- To see if there is interference of automaticity on speed of processing in the two groups.
- To see if there is semantic interference using Stroop effect in PWS compared to PWNS
- To see if there is any effect on cognitive loading (combined Simon and Stroop effect) in PWS compared to PWNS.

CHAPTER – 2

REVIEW OF LITERATURE

Most of us know what stuttering is but great deal of discrepancy results when we try to define what constitutes stuttering. Discrepancies in understanding and defining stuttering stem from conflicting inferences about the underlying nature of the disorder. A well accepted fact about stuttering is that it usually begins in childhood unless it is caused by a neurological insult or some psychogenic factors. Very rarely we see a person whose disorder clearly began during adulthood. When we do find such a person there is always some suspicion or even evidence to indicate that it is indeed a recurrence of a problem which had shown itself much earlier in the person's life. Early onset of stuttering is reported by many authors (Ambrose & Yairi 1994; Zebrowski, 1995; Van Riper 1971 & Yairi, Lewis, 1984.). According to Wingate (1976) it is well documented that children between 3-5 years experience periods of dysfluency, which vary often depending upon emotional and linguistic load present in community interaction.

Stuttering has been defined in many different ways mostly from the listeners' perspective as to the observable features of the problem. Some definitions focus on describing what happens during instance of stuttering both overtly and covertly, others focus on its dynamics. E.g. Wingate's definition (1964) addresses important factors such as stuttering behaviors, reactions and feelings. A long standing problem has been the absence of generally accepted description of definitive feature of stuttering.

The "standard definition" of stuttering which is more complex and cited often is the one given by Wingate (1964, p.486). It states: "the term 'stuttering' means: 1 (a) disruption in the fluency of verbal expression, which is (b) characterized by involuntary, audible or silent repetitions or prolongations in the utterance of short speech elements, namely; sound syllables and words of one syllable. These disruptions (c) usually occur frequently or are marked in character and (d) are not readily controllable. II. Sometimes the disruptions are (e) accompanied by accessory activities involving the speech apparatus, related or unrelated body structure or stereotyped speech utterance. These activities give the appearance of being speech – related struggle. III. Also, there not infrequently are (f) indications or reports of the presence of an emotional state, ranging from a general condition of "excitement" or "tension" two more specific emotions of a negative nature such as fear, embarrassment, irritation or the like, (g) the immediate source of stuttering is some in-coordination expressed in the peripheral speech mechanism; the ultimate cause is presently unknown and may be complex or compound."

Starkweather (1978) defined stuttering as disorder of fluency as: "Fluency is deviant when speech is produced with effort, when speech is more discontinuous than normal or when the discontinuities are immature, when rhythm of speech is atypical or when it is not serving the speaker by making the speech production easier".

Over view of stuttering Research

Puzzling nature of the disorder gained attention of professionals from many disciplines for centuries. Over the years many theories and models have been given to explain the nature of stuttering. One of the earlier models proposed that stuttering may be related to abnormal brain processes involved in speaking. Neurophysiological investigation of stuttering was pioneered by Lee. E. Travis at the University of Iowa. In an intensive research program that occupied the period from about 1927 to 1937, he and his students produced a steady output of laboratory findings. Orton and Travis (1928) speculated that stuttering resulted from incomplete development of hemispheric dominance. Travis (1934) recorded electrical potential from the left and right masseter muscles of PWS and PWNS when they were speaking. He found that recordings were essentially identical from both the sides for PWNS, as well as for the PWS when they were speaking normally. However, striking dissimilarities were found when there was a stuttering moment.

Apart from these perspectives, group of researchers considered a motoric component behind the origin of stuttering. If a PWS possesses a neuromuscular abnormality or weakness of some kind, its presence must be recognizable in the defective working of the oral structures. Many investigations were carried out to understand the laryngeal mechanism using different measures. Freeman and Ushijima (1975, 1978) conduced electromyographic studies in which they found PWS were slower in initiation as well as in terminating phonation when compared to PWNS. A bulk of research investigated the voice initiation time, voice termination time, oral and manual reaction and speech reaction time (SRT) to understand the neuromuscular or physiological aspect of stuttering (Adams & Hayden, 1976; Cross, 1978; Adler & Starkweather, 1979; Cross & Luper, 1979; Venkatagiri, 1982c; Cross & Luper, 1983; Peters & Hulstijn, 1987; Webster & Ryan, 1991). This vast amount of research failed to provide any conclusive evidence to prove any single/collective motoric component as the cause of stuttering.

Linguistic and language variables also play an important role in the moments of stuttering. Various studies have dealt with phonological, linguistic or language factors related to stuttering in children to see if there is any pattern to differentiate them from normally disfluent peers. There is continuing interest in the possibility that stuttering may be some form of language related variable (Logan, 2003; Padedn & Yairi, 1996; Wall & Meyers, 1982).

Two broad areas of language, that is, language development and language abilities have been investigated to explain cause of stuttering. Different components of language: phonology, syntax, semantics have also been investigated to understand the relationship between linguistics and stuttering.

Various workers have long believed that PWS frequently tend to be slow in developing language. The support for this view, though not qualified, has now become considerable. Berry (1938b) found very marked differences between PWS and PWNS. The Newcastle study again produced distinct evidence of slower speech development in PWS, corroborating Berry's findings as well as other past observations by Morely (1957) and Milisen and Johnson (1936). In the same line Westby (1979) reported children with stuttering (CWS) scored lower than children with no stuttering (CWNS) in frequency of grammatical errors, in receptive vocabulary on the Peabody Picture Vocabulary Test and incorrect responses on semantic task selected from the Torrance Test of Creative Thinking. Apparent lateness in acquiring language prompted series of investigations into language abilities of PWS/CWS.

But contrary to these findings, Peters (1968), Pitluk (1982) and Hanifi & Howell (1992) found no difference between children with stuttering and normal children in the language aspects investigated.

Psychological theories dominated stuttering literature for more than five decades. Stuttering was viewed as a learnt behavior (Bruten & Shoemaker, 1967; Shames & Sherrick, 1963). Many investigations probed attitude, personality, psychological adjustment, behavior of PWS in order to understand the nature and cause of stuttering. But the theories could not explain all the features of stuttering. Since there were no conclusive supports to the nature of stuttering by speech production theories, again in the early 1980's researchers probed into stuttering from motoric as well as linguistic perspectives.

For the past two decades there has been a growing interest on psycholinguistic approach in understanding the cause of stuttering. Many investigations have been carried out in understanding phonological, semantics, and syntactic processing in PWS/CWS and those who do not stutter. These investigations aimed at revealing some information about processing of language at a mental representation level

Priming effect and stuttering

Postma and Kolk (1993) proposed Covert Repair Hypothesis (CRH), which assumed phonological encoding to explain the cause of stuttering. According to this theory the selection of the phonological segments is disturbed due to slowing down in the activation of phonological segments. The retrieval of a word form can be envisioned as the spreading of activation in a network of nodes representing various units of phonological structure. Activation spreads down from the word meaning representation (lemma) to the segment nodes (Dell, 1986). Normally, at certain moment during phonological encoding, the segment that is most highly activated will be selected for inclusion in the articulatory plan. However, if activation builds up slowly, the activational competition between segmental representations may not have been settled when selection takes place, i.e., several segments have roughly equal activations. As a result, mis-selections occur more often than normal, which leads to errors in articulatory plan. To account for typical symptoms of stuttering, Kolk (1991) proposes that PWS detects these errors before they are uttered through internal monitoring. The detection of errors leads to the interruption of the speech output and to one or several attempts to revise and re-output the articulatory plan, which produces overt repetitions. Alternatively, the speaker may "hold" the speech output until the articulatory plan is appropriately fixed, which produces prolongation.

Wijnen and Boers (1994) hypothesized that stuttering is caused by a perturbation of phonological encoding. It was speculated that the construction of fully specified articulatory program on the basis of word form information stored in the mental lexicon is deviant in PWS. Phonological priming paradigm was used to investigate phonological encoding ability of both PWS and PWNS. Nine PWS and age and gender matched PWNS participated in the study. In each trial, they were required to utter one word from a set of five as fast as possible on visual presentation of the cue word. The experiment was divided into two blocks: One in which initial consonants were primed (the C-block) and in another block initial consonant and subsequent vowel was primed (CV-block). In each block there were two conditions homogenous and heterogeneous. In homogenous condition the response word shared initial segments with cue word. In heterogeneous condition the cue words were phonemically unrelated to target word. In each trial cue word was presented on the screen upon which occurrence the subjects were required to utter the associated response word as fast as possible. RT was calculated between the onset of the cue word and the onset of the spoken response. Results showed that in both C and CV block homogenous conditions produced shorter RT compared to heterogeneous conditions. In both the blocks PWS group showed longer RT in both the conditions (homo & hetero) compared to normal subjects. Priming magnitude was computed by subtracting RT of homogenous from heterogeneous condition. In both the blocks PWS showed lesser priming magnitude compared to normal subjects.

Burger and Wijnen (1999) aimed at investigating CRH & also aimed to replicate the study by Wijnen & Boers (1994). The second purpose was to examine the influence of stress upon phonological encoding. They found no statistically significant difference between PWS and normal subjects, thus concluding the notion that phonological encoding does not play a role in stuttering occurrence.

More recently Melnick, Conture and Ohde (2003) investigated the influence of phonological priming on speech reaction time (SRT) in CWS and CWNS using picture – word interference task. Participants were divided into 3-4, 4-5, 5- 6 years age groups. In their task the target picture was preceded by three conditions: a) no prime condition, in which only the pictures were presented, b) related prime condition in which the target picture was preceded by an auditory word which was related CV or CCV, c) unrelated prime condition where the target picture and prime word did not match phonologically. Total of 30 pictures were used in the experiment. Stimulus Onset Asynchrony (SOA) of 500 ms was used. The subjects' task was to ignore the auditorily presented words and name the picture as fast as possible. Results showed that CWS had longer reaction time in related and unrelated prime condition compared to CWNS group. CWS group showed lesser SRT in no prime condition compared to CWNS. But none of the conditions responses were statistically significant. Also, the SRT differences between unrelated prime and related prime showed no statistically significant difference between groups. It was concluded that Covert Repair Hypothesis (CRH) does not play a role in the cause of stuttering.

Increased RT may be explained in terms of Covert repair Hypothesis (CRH) proposed by Postma and Kolk (1993). They postulated that the phonological encoding plays a role in stuttering blocks. According to this theory (Covert Repair Hypothesis), PWS are slower in selecting phonemes during phonological encoding process.

Pellowski and Conture (2005) investigated the influence of lexical/semantic priming on speech reaction time of young children who do and do not stutter during a picture-naming task. 23 CWS and age matched (3;0 to 5;11 years) controls participated in the study. The procedure involved a computer-assisted picture-naming task during which each participant was presented with the same set of 28 pictures in each of 3 different conditions: a) no-prime condition, in which no auditory stimulus was presented before picture display; b) related-prime condition, in which a word, semantically related to the target picture, was presented auditorily 700 ms before picture display; and c) unrelated-prime condition, in which a semantically unrelated word was presented auditorily 700 ms before picture display. Results indicated that when compared with a no prime condition, presentation of semantically related words before the picture naming response led to shorter or faster speech reaction times for children who do not stutter, but for children who stutter, it led to longer or slower speech reaction times. Moreover, children who do not stutter and who had higher receptive vocabulary scores exhibited faster speech reaction time and a greater semantic priming effect whereas no such relationships were found for children who stutter. Findings were taken to suggest that children who stutter may exhibit subtle difficulties with lexical encoding and that this difficulty with speech-language planning may be one variable that contributes to stuttering.

Weber-Fox, Spencer, Spruill and Smith (2004) obtained Event Related brain Potentials (ERPs), judgment accuracy and reaction times (RTs) from 11 adults who stutter and 11 normally fluent speakers as they performed a rhyme judgment task of visually presented word pairs. Half of the word pairs (i.e., prime and target) were phonologically and orthographically congruent across words. That is, the words looked orthographically similar and rhymed (e.g., *thrown, own*) or did not look similar and did not rhyme (e.g., *cake, own*). The phonologic and orthographic information across the remaining pairs was incongruent. That is, the words looked similar but did not rhyme (e.g., *gown, own*) or did not look similar but rhymed (e.g., *cone, own*). Adults who stutter and those who are normally fluent exhibited similar phonologic processing as indexed by ERPs, response accuracy and RTs. However, longer RTs for adults who stutter indicated their greater sensitivity to the increased cognitive loads imposed by phonologic/orthographic in-congruency. Also, unlike the normally fluent speakers the adults who stutter exhibited a right hemisphere asymmetry in the rhyme judgment task, as indexed by the peak amplitude of the rhyming effect (difference wave) component. Overall, these findings do not support theories of the etiology of stuttering that posit a core phonologic-processing deficit. Rather, they provide evidence that adults who stutter are more vulnerable to increased cognitive loads and display greater right hemisphere involvement in late cognitive processes.

These experiments aimed at investigating processing of language components at the level of mental representation that is well before overt production. Priming effects are nothing but inhibitory or facilitatory effects of distracters upon target stimuli. Understanding the priming effects (phonology/semantics/syntax) directly probes the cognitive processing of language.

These investigations have failed to yield any conclusive evidence about problems occurring at the level of processing. This may be due to the fact that language is a complex process. Speech and language production involves great amount of cognitive processes. Before probing language processing at a mental representation level, it will be useful to understand the basic processes of cognition in CWS, adult PWS and PWNS.

Understanding the cognitive processes in individuals with communication disorder might help speech language pathologist to better understand the nature, cause and planning effective management programs.

Cognition

Cognition refers to the mental processes involved in gaining knowledge and comprehension, including thinking, knowing, remembering, judging and problem solving. Cognition is very important to constantly monitor, receive and process information from the environment. These are higher-level functions of the brain and encompass language, imagination, perception, and planning. Cognitive processes include attention, perception, memory, learning, problem solving, and decision making. Attention plays a major role in selecting a desired stimulus by ignoring irrelevant/undesired stimulus. Thus, understanding mechanism involved in attention is warranted.

1. Attention

Human attention has been extensively studied by investigators from many disciplines. Attention mechanisms have been considered as guided by *perceptual* and *cognitive* processes. The research results obtained so far and their connections and implications are far too many.

Attention as selection: There is no agreed upon definition of attention. However, most researchers refer to attention as the set of processes enabling and guiding the selection of incoming perceptual information. For example, Posner (1982) stresses the fact that attention is selective, has limited capacity, is related to both reactive and deliberative processes and it is associated with both inhibitory and facilitating effects. Driver (2001 p. 53) defines "Research on attention [as] concerned with selective processing of incoming sensory information". Lavie and Tsal (1994, p. 183) see "Selection of information [as] the primary concern of attention research". Chun and Wolfe (2001, p. 273) propose that “First, attention can be used to select behaviorally relevant information and/or to ignore the irrelevant or interfering information. Second, attention can modulate or enhance this selected information according to the state and goals of the perceiver. With attention, the perceivers are more than passive receivers of information. They become active seekers and processors of information, able to interact intelligently with their environment”. Three aspects of attention seem to be commonly recognized as fundamental: selection, awareness and control (Baddeley & Weiskrantz, 1993; Parasuraman & Davis, 1984).

Interference effects, helps to explain why we do not always manage to keep attention on a target stimulus nor can we consistently avoid distracters. Interference effects are delays in the processing of stimuli due to unwanted stimuli called *distracters*. How much interference a distracter will generate appears to be a function of personal experience and the environment. Rafal and Henik (1994), for example, observe that distracters may delay the processing of stimuli especially when they are temporally near and conceptually related to the target stimulus. Classic examples of interference are *negative priming* (Tipper, 1985) and the *Stroop effect* (Stroop, 1935). Negative priming is an effect by which "it is more difficult to select a stimulus belonging to a given category, for the control of action, if that same category of object was actively ignored on the preceding trial" (Allport, 1989, p.659; quoted in Arvidson, 2003, p.114). The *Stroop effect* (Stroop, 1935) is a visual inhibition effect that occurs when a presented word indicates a different color than the actual color of the font used to spell it.

2. Information Processing:

Information processing is used in all cognitive activities including perceiving, rehearsing, thinking, problem solving, remembering, forgetting and imaging (Schunk, 2004). When we deal with information, we do so in steps. One way to think of this is to picture the process of acquiring, retaining, and using information as an activity called information processing, which is diagrammed in Figure 6.1. Information comes from the outside world into the sensory registers in the human brain. This input consists of things perceived by our senses. We are not consciously aware of most of the things we perceive; we become aware of them only if we consciously direct our attention to them. When we do focus our attention on them, they are placed in our *working memory*. Figure 2.1 shows a simple model of information model based on memory.

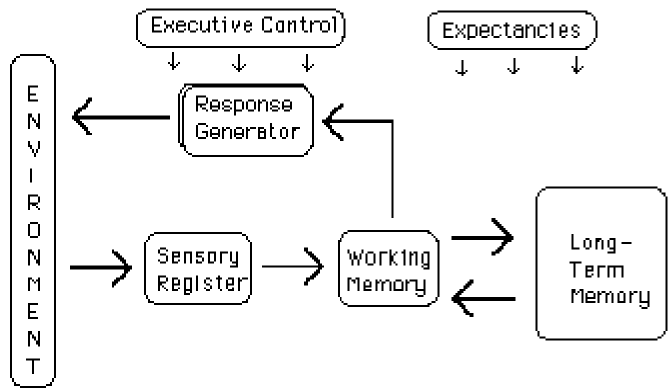

Figure 2.1: A model of human information processing

3. Memory:

In psychology, memory is an organism's mental ability to store, retain and recall information. There are generally three types of memory: *sensory memory*, *short-term memory* and *long-term memory*.

Another name for our working memory is *short-term memory*. Our working memory has a very limited capacity - we can attend to only about seven items at a time. Therefore, we must take one of the following actions with regard to each piece of information that comes into this short-term storage area: (1) continuously rehearse it, so that it stays there; (2) move it out of this area by shifting it to long-term memory; or (3) move it out of this area by forgetting it.

Long-term memory, as its name implies, stores information for a long time. The advantage of long-term memory is that we do not have to constantly rehearse information to keep it in storage there. In addition, there is no restrictive limit on the amount of information we can store in long-term memory. If we move information to long-term memory, it stays there for a long time - perhaps permanently! To make use of this information in long term memory, we must move it back to our working memory, using a process called *retrieval*.

It may be convenient to view information processing as parallel to the way in which an executive manages a business. Information comes into the business across the executive's desk - mail, phone calls, personal interactions, problems, etc. (This is like short-term memory.) Some of this information goes into the waste basket (like being forgotten), and some of it is filed (like being stored in long-term memory). In some cases, when new information arrives, the executive gets old information from a file and integrates the new information with the old before refilling it. (This is like retrieving information from long-term memory to integrate it with new information then storing the new information in long-term memory.) On other occasions the executive may dig out the information in several old files and update the files in some fashion or integrate them in some way to attack a complex problem. The business of human learning operates in much the same manner.

In the field of cognitive psychology, cognitive neuroscience, psychology and speech language pathology different paradigms like Simon, Stroop, finger tapping, etc., have been used to investigate the cognitive ability of individuals. Since the present study focuses on Simon and Stroop tasks, further elaborations on these tasks are warranted.

A simple information processing model includes an input, central executive processor, and output. The central executive processor includes three components (Henry & Rogers, 1960):

- Stimulus identification stage (sensation and perception) – recognize and identifies the input.
- Response-selection stage – decides what response should be made.
- Response-programming stage (response execution) – organizes the motor system to produce a desired movement.

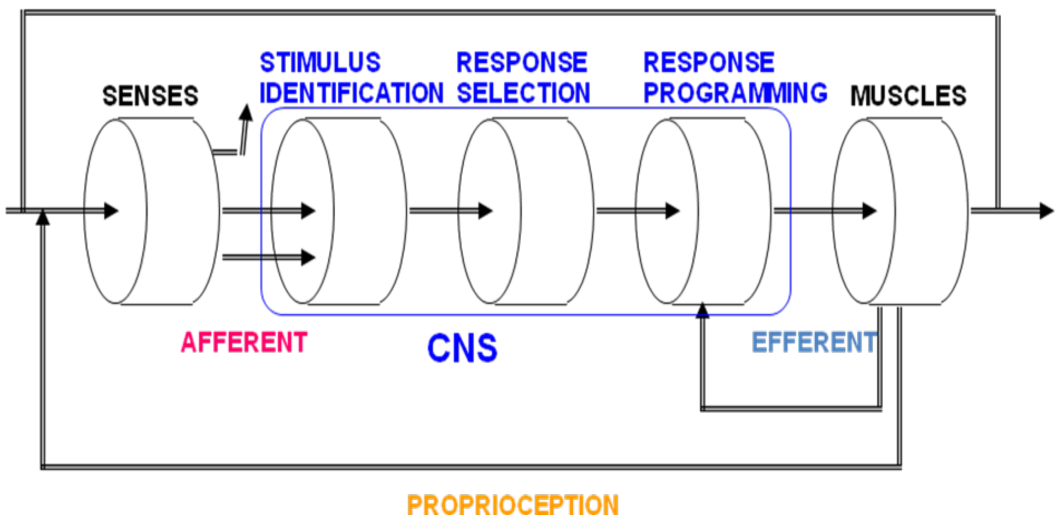

Figure 2.2: Simple information processing model

Processing of any information involves cognition and it is central for any processing and planning of motor or speech execution. Simon task and Stroop task are the paradigms which can be used to investigate information processing. The combination of stimuli and a response is a major determinant of performance. Stimulus – Response Compatibility (SRC) research has established that the task performance is superior when the presented stimulus is somehow similar to the required response than when the stimulus and the response are dissimilar. This is termed as Simon task (Simon, 1990).

I. Simon task:

In a version of the Simon task (Simon, 1969) subjects are instructed to press the left button to a red circle and the right button to a blue circle appearing on the screen. The positions of the circles relative to the central fixation point are varied randomly. Although the color of the signal is the only relevant aspect of the signal, performance is hampered by the (task-irrelevant) position of the signal. The processing of the (irrelevant) location of the circle interferes with the processing of the color (relevant information). In the Simon task, responses to signals that are presented on a location that corresponds with the correct response hand (i.e., congruent trials) typically are faster than when location and response hand do not agree (i.e., incongruent trials).

Based on a large amount of data, it is typically assumed that the Simon effect is caused by the parallel activation of two “routes” from perception to action. In the “conditional” route, the appropriate response is activated by a relatively slow intentional process. In the “unconditional” route, the response that corresponds to the stimulus location is activated in a relatively quick and automatic fashion (de Jong, Liang & Lauber, 1994; Eimer, 1995; Kornblum, 1994; Kornblum, Hasbroucq & Osman, 1990; Ridderinkhof, 2002b; Wiegand & Wascher, 2005).

Processing along the unconditional route is thought to occur because of dimensional overlap (Kornblum, 1994; Kornblum et al., 1990). That is, the response set and the irrelevant stimulus share a dimension – location and this shared dimension primes the associated response. Participants encode and maintain the task-relevant responses using a spatial code and because the irrelevant stimulus varies along the dimension of this spatial code, these two (response set and irrelevant stimulus dimension) automatically become associated with one another. As a result, the location of each relevant stimulus quickly and automatically activates the corresponding response. In contrast, participants are only able to activate the correct response relatively slowly, based on strategic, task-dependent mechanisms (de Jong et al., 1994; Eimer, 1995; Ridderinkhof, 2002b; Wiegand & Wascher, 2005).

In fact, interference tasks such as the Stroop, Simon are based on the notion that an irrelevant stimulus dimension activates an associated response by a fast and automatic process, while the relevant stimulus-response mapping proceeds much slower – although there are other forms of dimensional overlap which might also contribute to the specific performance on such a task (Kornblum et al., 1990; Kornblum, Stevens, Whipple & Requin, 1999). During incongruent trials, the two responses conflict with one another (Coles, Gratton, Bashore, Eriksen & Donchin, 1985) and it takes time for the correct stimulus-response mapping to override the incorrect response activation. As this fast activation of the incorrect response sometimes reaches response threshold, there are more errors in the incongruent condition than in the congruent condition; moreover, these errors tend to be fast (e.g., Gratton et al., 1988; Ridderinkhof, 2002b).

Superficially, the Simon effect may seem similar to the Stroop effect. However, it is generally accepted that the interference that occurs in the Stroop effect comes from the stimulus identification, while the interference that occurs in the Simon effect occurs in the response selection stage. During response selection, a person uses a rule to translate the relevant stimulus dimension, usually shape or color, to the correct left or right response.

However, the location dimension of the stimulus (its position on the screen) overlaps with the relevant stimulus dimension (left or right). Because of this, the irrelevant location dimension of the stimulus activates the corresponding response and interferes with making a response to the non-corresponding side. Because of this, same side responses are faster and more accurate than responses that are made opposite the location of the stimulus. Primarily Simon effect shows that the location information cannot be ignored and will affect decision making even if the user knows that the information is irrelevant.

As a measure of interference, the Simon effect has several advantages over other tasks. Because it is relatively content free, participants can be asked to make almost any perceptual discrimination. The only requirement is that the stimuli and responses have corresponding and non-corresponding locations. Thus, unlike interference from the Stroop effect, which is dependent on verbal ability and literacy, the Simon effect can be studied in language-impaired individuals or illiterates. Tasks measuring the Simon effect can also be very simple and do not require the participant to refrain from making a natural response in favour of an unnatural one, as required in studies of stimulus-response compatibility. The simplicity of the possible perceptual discriminations and response requirements that can be used to generate a Simon effect makes it highly suitable for exploring filtering or interference in participants with limited ability to comprehend or carry out complex instructions, such as young children, elderly people, and individuals with brain disorders.

As mentioned earlier studying the Simon effect gives us insight into a stage of decision making called "response selection." According to information processing theory, there are three stages of decision-making: Stimulus identification, response selection and response execution or the motor stage.

Processing stage at which the effect occurs:

Historically, the Simon effect has been considered to be a response-selection phenomenon, in part because effects of similar nature are obtained when stimulus location is the relevant attribute for determining the response. In two-choice tasks for which location is the relevant stimulus dimension, responses are faster if the left stimulus is assigned to the left response and the right stimulus to the right response than if the assignments are reversed (Proctor & Dutta, 1993). Considerable evidence indicates that such spatial compatibility effects (sometimes called *S–R compatibility proper*) are attributable to response-selection processes (Proctor & Reeve, 1990). Among other things, the effects of S–R compatibility proper typically are independent from those of variables whose effects are on stimulus-identification or response-execution processes (Hasbroucq, Guiard & Kornblum, 1989; Spijkers, 1990). The Simon effect has similarly been found to be independent from effects of identification and execution variables, in at least some cases. For example, Simon and Berbaum (1990) conducted experiments in which subjects pressed a left or right key in response to color Stroop stimuli (color words printed in congruent or incongruent ink colors) presented at the left or right side of the display. Half of the subjects responded to the ink color and half to the color word. Within subject independent variables included (1) the congruity between the relevant and irrelevant stimulus dimensions (i.e., the color word and the ink color), (2) the spatial correspondence between the irrelevant stimulus location and the response location and (3) the stimulus duration. The results for the two task variations were similar, showing significant main effects of dimensional congruity, spatial correspondence and stimulus duration, but no interactions. Because spatial correspondence and congruity did not interact with stimulus duration, which is customarily assumed to affect the time for stimulus identification, Simon and Berbaum concluded that neither the Simon effect nor the congruity effect were a function of stimulus-identification processes. As another example, Guiard (1983) demonstrated a Simon effect of 53 msec for clockwise and counter-clockwise wheel rotation responses made to low- and high-pitched tones presented to the left or right ear. Clockwise responses were initiated faster to stimuli presented to the right ear, whereas counter-clockwise responses were initiated faster to stimuli presented to the left ear. No similar effect of the ear in which stimuli were presented was apparent in the rotation amplitudes of the responses. Guiard interpreted this pattern of results as indicating that the Simon effect is due to response selection rather than response execution and attributed it to response competition (Umiltà & Nicoletti, 1990). The accounts assume that a response code is generated for the irrelevant stimulus location attribute, although they differ in the reasons proposed for how and why the code is generated. For trials on which the irrelevant response code corresponds with the response code signalled by the relevant stimulus dimension, there is no competition and possibly even a benefit from the redundant response codes. However, for trials on which the irrelevant response code does not correspond with the relevant response code, it produces competition that must be resolved before the correct response can be made. It is this response competition that is assumed to be the primary cause of the slower RTs for the non-corresponding trials relative to the corresponding trials.

Research with children has addressed the cognitive impact of bilingualism more directly. Bilingual advantages have been reported across a variety of domains, for example, creativity (Kessler & Quinn, 1987), problem solving (Bain, 1975; Kessler & Quinn, 1980) and perceptual dis-embedding (Duncan & De Avila, 1979). Positive effects for bilinguals, however, have not always been found; some studies reported negative effects (Macnamara, 1966) and others found no group differences (Rosenblum & Pinker, 1983). The disparate findings can be resolved by considering the cognitive processes implicated in the various tasks used to assess the effects of bilingualism.

Bialystok, Craik, Klein and Viswanathan (2004) attempted to determine whether bilingual advantage persists for adults and whether bilingualism attenuates the negative effects of aging on cognitive control in older adults. Three studies are reported that compared the performance of monolingual and bilingual middle-aged and older adults on the Simon task. Bilingualism was associated with smaller Simon effect costs for both age groups; bilingual participants also responded more rapidly to conditions that placed greater demands on working memory. In all cases the bilingual advantage was greater for older participants. It appears, therefore, that controlled processing is carried out more effectively by bilinguals and that bilingualism helps to offset age-related losses in certain executive processes.

Mullane, Corkum, Klein and McLaughlin (2008) examined two reaction-time-based interference control paradigms, known as the Eriksen Flanker task and the Simon task, in children with and without ADHD. Combining twelve studies, yielding a combined sample size of 272 children with ADHD (M age 9.28 yrs) and 280 typically developing children (M age 9.38 yrs). It was predicted that, specific disadvantages were found in the

ADHD group in terms of reaction time, percentage of errors and efficiency of performance on incongruent relative to congruent trials, providing evidence for weaker interference control in this group.

Schmiedt-Fehr, Schwendemann, Herrmann and Basar-Eroglu (2007), investigated event-related oscillations associated with a Simon task in 11 patients with Parkinson's disease, 11 age-matched and 11 young normal participants. During this task, participants responded faster when the relative spatial positions of stimulus and response match (no response conflict exists) than when they do not match (response conflict exists). An increased response conflict (increase in reaction times known as Simon effect) was found in elderly control and patients with Parkinson's disease compared with young participants. Group and condition differences were found in the δ and θ frequency range, which may reflect that Parkinson's patients and matched controls use different cognitive strategies for stimulus-response processing than young controls and neuro-physiological correlates of such strategy are deficient in patients compared with age-matched controls.

Castel, Balota, Hutchison, Logan and Yap (2007) examined the degree to which aging and Alzheimer's disease (AD) influence the ability to control attention when conflict is presented in terms of incongruent mapping between a stimulus and the appropriate response. In a variant of the Simon task, healthy older adults and older adults with mild or very mild AD showed disproportionately larger reaction time (RT) costs when the stimulus and response were in conflict relative to RT costs of healthy younger adults. Analyses of RT distributions provide support for a 2-process model of the Simon effect in which there is a short-lived transient effect of the irrelevant dimension in younger adults and a more sustained influence across the RT distribution in older adults.

An analysis of error rates showed that the older adults with mild and very mild AD made more errors in incongruent trials, suggesting that AD leads to increased likelihood of selecting the pre-potent pathway.

Germain and Collette (2008) used an adaptation of the Simon task to differentially assess perceptual and motor inhibition using the same stimuli and task design and to determine whether these processes use separate or shared cognitive resources. They were interested in determining whether (1) normal aging is associated with the use of separate (as previously evidenced in young participants) or similar cognitive resources to perform perceptual and motor inhibition tasks; (2) older participants present a specific impairment in one of these two processes. Analyses of reaction times indicated that motor and perceptual inhibitory processes share some cognitive resources and both are impaired in normal aging. These results can be interpreted by considering that a dedifferentiation process is responsible for the inhibitory deficits presented by older participants.

There are now studies of differences in interference using the Simon effect paradigm in normal aging (Van der Lubbe & Verleger, 2002) as well as patient groups such as children with developmental disorders (Mandich, Buckolz & Polatajko (2003), adults with schizophrenia (Gastaldo, Umilta, Bianchin & Prior, 2002), Parkinson's (Praamstra & Plat, 2001), Huntington's and Tourette's (Georgiou, Bradshaw, Phillips & Chiu, 1995; Cope, Georgiou, Bradshaw, Iansek & Phillips, 1996).

Above mentioned brief review clearly indicates as well as throws some light on some abnormality in cognitive processes in disordered population as well as improved cognitive processes in bilinguals. No investigations have been carried out to explain or explore the cognitive processes using Simon task on PWS. This dearth of information necessitated to carry out a study which can probe the cognitive processes in PWS. The present study aimed to investigate cognitive ability of PWS and PWNS using Simon task.

II. Stroop task

The Stroop effect is a demonstration of interference in the reaction time of a task. When a word such as blue, green, red, etc. is printed in a color differing from the color expressed by the word's semantic meaning (e.g. the word "red" printed in blue ink), a delay occurs in the processing of the word's color, leading to slower test reaction times and an increase in mistakes. The effect is named after John Ridley Stroop who first published the effect in English in 1935. The effect had previously been published by Jaensch in 1929, but only in German.

This interference is observed due to:

- Word reading is automatic and obligatory whereas color naming is a more controlled process. So, response for word reading reaches response stage before response for color naming. This leads to interference effect.
- Automatic processes can interfere with controlled processes, but not vice versa.

Many researchers now agree that the locus of the Stroop effect is at the level of the response selection (Fagot & Pashler, 1992; Kuipers, La heij & Costa; Macleod, 1991; Roelofs 2003). That is, the Stroop interference comes about because an incorrect response possibility triggered by the distracter interferes with the correct response that is triggered by the target stimulus. Words are read faster than colors are named.

The nature of attention has been one of the central concerns of processing (Cattell, 1886; Pillsbury, 1908). James (1890) emphasized the selective aspects of attention and regarded attention as a process of "taking possession by the mind, in clear and vivid form, of one out of what seems several simultaneously possible objects or trains of thought" (p. 403). Others, such as Moray (1969) and Posner (1975) have noted that attention is also a heightened state of arousal and that there appears to be a limited pool of attention available for cognitive processes. Posner and Snyder (1975) and Shiffrin and Schneider (1977) have provided accounts of attention that integrate these aspects of attention and emphasize that attention is intimately tied to learning. These accounts focus on two types of cognitive processes, controlled and automatic. *Controlled processes* are voluntary, require attention and are relatively slow, whereas *automatic processes are* fast and do not require attention for their execution because they are involuntary. Performance of novel tasks is typically considered to rely on controlled processing; however, with extensive practice, performance of some tasks can become automatic (LaBerge & Samuels, 1974; Logan, 1978; Posner & Snyder, 1975; Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977).

A more general approach to explaining Stroop-like effects has been to consider the role of attention in processing. This approach draws on the distinction between automatic and controlled processes (Cattell, 1886; Posner & Snyder, 1975; Shitfrin & Schneider, 1977). The results of an automatic process are more likely to escape attempts at selective attention than are those of a controlled process. Posner and Snyder (1975) applied the distinction between controlled and automatic processes directly to the Stoop task by making the following three assumptions: (a) Word reading is automatic, (b) color naming is controlled, and (c) if the outputs of any two processes conflict, one of the two processes will be slowed. In this view, the finding that word reading is faster than color naming follows from the relatively greater speed of automatic processes. The finding that ink color has no effect on word processing follows from the assumption that color naming is controlled and therefore voluntary; so, the color-naming process will not occur when the task is to ignore the color and read the word. The finding that a conflicting word interferes with color naming follows from the automaticity (i.e., involuntary nature) of word reading and the assumption that conflicting outputs slow responding. This interpretation of the Stroop task exemplifies a general method that has been used for assessing the automaticity of two arbitrary processes, A and C, on the basis of their speed of processing and the pattern of interference effects they exhibit. If A is faster than C, and if A interferes with C but C does not interfere with A, then A is automatic and C is controlled. Of course, this reasoning requires that Processes A and C are in some sense comparable in intrinsic difficulty and number of processing stages. This method for identifying processes as automatic or controlled has gained wide acceptance.

The Processing Framework

- **a.** Architectural characteristics: Processing within the PDP framework is assumed to take place in a system of connected modules. Each module consists of an ensemble of elementary processing units. Each unit is a simple information-processing device that accumulates inputs from other units and adjusts its output continuously in response to these inputs.
- **b.** Representation of information: Information is represented as a pattern of activation over the units in a module. The activation of each unit is a real valued number

varying between a maximum and minimum value. Thus, information is represented in a graded fashion and can accumulate and dissipate with time.

c. Processing: Processing occurs by the propagation of signals (spread of activation) from one module to another. This occurs via the connections that exist between the units in different modules. In general, there may be connections within as well as between modules, and connections may be bidirectional.

d. Pathways and their strengths: A particular process is assumed to occur via a sequence of connected modules that form a pathway. Performance of a task requires that a processing pathway exist that allows the pattern of activation in the relevant sensory modules to generate through propagation of activation across intermediate modules-an appropriate pattern of activation in the relevant output modules. The speed and accuracy with which a task is performed depends on the speed and accuracy with which information flows along the appropriate processing pathway. This in turn depends on the connections between the units that make up the modules in that pathway. This is referred to as the strength of a pathway. Thus, the speed and accuracy of performing a task depend on the strength of the pathway used in that task.

e. Interactions between processes: Individual modules can receive input from and send information to several other modules. As such, each can participate in several different processing pathways. Interactions between processes arise in this system when two different pathways rely on a common module, that is, when pathways intersect. If both processes are active and the patterns of activation that each generates at the point of intersection are dissimilar, then interference will occur within that module and processing will be impaired in one or both pathways. If the patterns of activation are very similar, this will lead to facilitation. The intersection between two pathways can occur at any point in processing after the sensory stage. Interference at the output stage would give rise to response competition, such as that observed in the Stroop task (Dyer, 1973). The general view that interference effects arise whenever two processes rely on a common resource or set of resources has been referred to as the multiple-resources view (Allport, 1982; Hirst & Kalmar, 1987; Navon & Gopher, 1979; Wickens, 1984). Different tasks may depend on different resources, and dual-task interference occurs only when the tasks share common resources. Thus, the interference a particular task produces will not be an invariant characteristic of that task; rather, it will depend on the nature of the tasks it is combined with.

f. Attentional control: One way to avoid the interactions that occur at the intersection between two pathways is to modulate the information arriving along one of them. This is one of the primary functions of attention within this framework and is consistent with the views on attention expressed by several other authors (Kahneman & Treisman, 1984; Logan, 1980; Treisman, 1960). In this way, attention can be used to control individual processes. However, this does not necessarily imply that attention requires a unique or even distinct component of processing. Attention can be thought of as an additional source of input that provides contextual support for the processing of signals within a selected pathway. This framework can be used to account for many of the empirical phenomena associated with learning and automaticity (Cohan, Dunbar & McClelland, 1990; Rumelhart, Hinton & McClelland 1986).

The accurate perception of speech involves the processing of multidimensional information. Jerger, Kent, Albritton, Loiselle, Blondeau and Jorgenson (1993) aimed to determine the influence of the semantic dimension on the processing of the auditory dimension of speech by children with hearing impairment. The processing interactions characterizing the semantic and auditory dimensions were assessed with a pediatric auditory Stroop task. The subjects, 20 children with hearing impairment and 60 children with normal hearing were instructed to attend selectively to the voice-gender of speech targets while ignoring the semantic content. The type of target was manipulated to represent conflicting, neutral and congruent relations between dimensions (e.g., the male voice saying "Mommy," "ice cream," or "Daddy" respectively). The normal-hearing listeners could not ignore the irrelevant semantic content. Instead, reaction times were slower to the conflict targets (Stroop interference) and faster to the congruent targets (Stroop congruency). The subjects with hearing impairment showed prominent Stroop congruency, but minimal Stroop interference. Reduced Stroop interference was not associated with chronological age, a speed-accuracy tradeoff, a non-neutral baseline, or relatively poorer discriminability of the word input. It was suggested that the voice-gender and semantic dimensions of speech were not processed independently by these children, either those with or without hearing loss. However, the to-be-ignored semantic dimension exerted a less consistent influence on the processing of the voice-gender dimension in the presence of childhood hearing loss. The overall pattern of results suggested that speech processing by children with hearing impairment is carried out in a less stimulus-bound manner.

Caruso, Chodzko-Zajko, Bidinger and Sommers (1994) investigated the effects of speed and cognitive stress on the articulatory coordination abilities of adults who stutter. Cardiovascular (heart rate, systolic and diastolic blood pressure), behavioral (dysfluencies, errors, speech rate and response latency) and acoustic (word duration (WD), vowel duration (VD), consonant-vowel transition duration/extent and formant center frequency) measures for nine PWS and nine PWNS were collected during performance of the Stroop Color Word task. Modified Stroop Color word task consisted of one control condition (CON) and three conditions of increasing cognitive difficulty: a) the black and white word reading condition (BW); b) the color naming condition (CX); and c) the Stroop word condition (ST). For the CON (self – paced) condition, a 20 – item matrix of the words RED, YELLOW, BLUE and GREEN printed on one sheet of paper was presented to the subjects to read once at a comfortable speech rate. For the BW, CX and ST conditions, matrices of 28 items in random order were presented continuously for 10 minutes on a microcomputer monitor. In the BW condition the subjects read aloud the words RED, YELLOW, BLUE and GREEN, displayed in white ink on the black computer screen. For the CX condition, they named the ink color of RED, YELLOW, BLUE and GREEN Xs. For the ST condition, they named the ink color of the words RED, YELLOW, BLUE and GREEN, with the ink color and word name being incongruent, For example, if the word RED was printed in YELLOW ink, the correct would be “YELLOW”. Unlike the CON condition, the three experimental conditions were speed tasks and the subjects were instructed to read (BW) or name (CX and ST) the colors as rapidly as possible while remaining accurate in their answers. Mixed ANOVAs of word duration (WD) and (VD) showed no significant group * condition interaction effects; however, significant group effects as well as significant condition effects for both WD and VD measures were found. The mean WD and VD were longer for PWS than the mean WD and VD for PWNS. Tukey (b) means showed PWS had longer WD and VD in WB and WT conditions.

Results from mixed ANOVAs of the consonant-vowel transition extent (EXT) and transition duration (TRD) measures indicated no significant group effect as well as no significant group * condition interaction effect for either measure: however, significant condition effects were revealed for both EXT and TRD. In essence, both groups took longer to move the articulators farther for the consonant vowel transition in the ST condition than in either the CON or BW conditions. Results from the separate ANOVAs of the first formant and the second formant center frequency data failed to reveal significant group or group * condition interaction effects for either measure. The condition effect for formant 2 was also not significant, however a significant condition effect was found for formant 1. It was concluded that presence of cognitive stress resulted in greater temporal disruptions and more dysfluencies for PWS than for normally fluent speakers. However, similar spatial impairments were not evident. These finding support the contention that stuttering is a disorder of timing.

Leverett, Lassiter and Buchanan (2002) assessed possible implications regarding the assessment of reading achievement. They examined the relationships for scores on the Stroop Color and Word Test with measures of reading and language achievement within an adult population. The Stroop Color and Word Test, Nelson-Denny Reading Test, Woodcock-Johnson Psycho-Educational Battery-Revised and Wide Range Achievement Test-3 were administered to 99 men ranging in age from 18 to 27 years. Pearson product-moment correlations indicated that the Stroop Word task was positively associated with scores on the WRAT-3 Spelling task, the Woodcock-Johnson Basic and Broad Reading tasks, and the Nelson-Denny Reading Rate and Comprehension tasks.

Stroop task has been used to investigate language and cognitive ability of different population. Adams and Jarrold (2009) investigated the inhibition ability of children with autism. Using the classic Stroop, children with autism (CWA) were found often to out-perform typically developing children (TDC). A classic Stroop and a chimeric animal Stroop were used to explore the validity of the Stroop task as a test of inhibition for CWA. During the classic Stroop, children ignored the word and named the ink color, then vice versa, that is reading the word by ignoring the color. Although CWA showed less interference than TDC when naming color, both groups showed comparable interference when reading word. During the chimeric animal task, children ignored bodies of animals and named heads, and vice versa; the groups performed comparably. Findings confirm that lower reading comprehension affects Stroop interference in CWA, potentially leading to inaccurate conclusions concerning inhibition in CWA.

Christiansen and Oades (2009) investigated the effect of Negative Priming (NP) response latency in children with Attention Deficit Hyperactivity Disorder (ADHD). Response times in NP task conditions were compared with the interference provided by congruent/incongruent stimuli in a Stroop condition in the same task in children diagnosed with ADHD, their unaffected siblings and independent controls. Speed, accuracy, and variability of responses were compared using a computerized NP Stroop test for 35 children with ADHD, 24 siblings without diagnosis and 37 independent healthy controls aged 6 to 17 years. Results revealed that NP was evident at test onset for congruent trials in children without a diagnosis and was reduced initially in those with

ADHD occurring in the absence of a significant Stroop interference effect and independently of age or symptom severity. In-congruency masked NP effects. Cases showed more intra individual response-time variability. It was concluded that both NP in normal children and its reduction in ADHD cases attenuated across trials reflecting the increased facilitation from previous stimulation.

Subramanian and Yairi (2006) aimed to identify traits associated with stuttering. Their study used two different tasks-a tapping task that is thought to probe hemispheric differences and the Stroop task, which appears to create interferences in speech motor programming and/or execution. 48 adult participants divided into 4 different groups with 12 subjects in each a) Experimental A: individual who stutter, b) Control A: individuals who do not stutter, c) Experimental B: relatives of individuals who stutter with high risk for stuttering and d) Control B condition: individuals who do not stutter. In stroop task the basic procedure involves visual representation of words. For example, the word “green” is presented in red or in green letterers. The subject is to say the name of the color that the word appeared in, irrespective of the word itself. The reaction time is measured and the number of errors tabulated. The task is assumed to provide a measure of interference in the process of retrieval and production of different, but related words. A longer reaction time is expected when such interference in speech is noticed. In as much as both word-retrieval (Hubbard & Prins, 1994) and encoding (Postma & Kolk, 1993) have been implicated in stuttering, this task appeared suitable. A software program especially developed for the task was used in the study. Fifty pre-selected words appeared on the computer, one at a time, at intervals of 1.5 secs. A head set microphone (AKG C 420) connected to a tape recorder (Sony TC-RX70ES) was provided to subjects to record their naming of the color of the word that appeared on the monitor. The word list included control words (“red” written in red) and conflict colors (“red” written in green). The occurrence of each word is signaled by a click, not heard by subject, recorded on the audiocassette along with the subject’s response.

Results indicated that the reaction time was greater for conflict condition. Unexpectedly, the stuttering group had shorter RTs when compared to its control group and the high risk group. Specifically, in the conflict condition, the stuttering group exhibited shortest RTs. When the ratios of the conflict- to – congruent reaction time were calculated, the stuttering group yielded a ratio of 1.16; it was 1.14 for the high risk group. The ratios for the control groups were 1.22 and 1.26, respectively. Thus, the conflict condition did not affect the reaction time for the experimental groups to the extent it did for the control groups. Accuracy values were 100% for all groups in the congruent condition. In fact, accuracy was high for all groups in all other conditions too, although still lowest for the conflict condition.

Condition was found to be statistically significant (F = 46.45, df 1,42m, p<.000). A non-significant interaction between group and condition (F = 1.41, df 3,42, p = 0.255) indicates that the measures of RT did not vary among the groups. The between subject variable of group was found to be non-significant (F = 0.84, df 1,42, p = 0.481).

Based on these results investigators speculated that when placed under external interferences, people who stutter may use different speech motor control (including stages of processing, planning, and production) strategies that result in lower reaction time for this group.

CHAPTER – 3

METHOD

The Present study aimed at investigating information processing ability of PWS and PWNS using Simon and Stroop tasks. RT was measured across three tasks which had linguistic and non linguistic stimuli. Each task had 2- color condition (2, 4) and three conditions (control, congruent and incongruent conditions).

Participants: Participants consisted of two groups - experimental and control group.

Experimental group

15 PWS in the age range of 18 to 30 years were considered for the experiment. All the participants were males. Participants were taken from those who registered at AIISH clinic for fluency evaluation and those who were recently enrolled for therapy at the clinic. All the participants were native Kannada speakers.

Selection criteria for experimental group

The subjects fulfilled the following criteria to be included in the study:

- Normal hearing sensitivity
- No cognitive deficit
- No neurological deficits
- No orofacial anomalies
- Normal vision or corrected vision
- No participation in any of the fluency shaping/modification therapy at least for one year prior to the experiment. and
- Should be literate (high school) and be able to read English and

- Should be diagnosed as having mild to severe degree of stuttering by a qualified SLP at the time of inclusion.

Control group:

15 age and gender matched PWNS were considered for the control group. Selection criteria were same as for the experimental group except that the control group participants had no fluency disorder.

Instrumentation: The experiment was carried on a computer with 15” color monitor. The sequence of events and collection of data was randomized and controlled by using software DMDX (3.0).

Materials: 5 cm squared color blocks in red, black, brown, green, blue, yellow, and colored words in Aerial font, font size 14, bold and capital words in the same color as of the blocks were also used.

Procedure: The standard procedure recommended for testing Simon and Stroop task was employed as follows (Simon, 1960 & Stroop 1935):

The present experiment consisted of three tasks. Task I was a Simple task which used colored blocks. Task II was also same as task I, but used color words instead of blocks. Task III involved both Simon task and Stroop task. Participants were made to sit in front of the monitor on a comfortable arm chair. Care was taken to provide adequate ventilation and light.

Task I: This task consisted of four conditions, which are as follows:

A. Control 2 condition: A series of squares either red or black appeared in the center of the screen for 2000 ms. Participants were instructed to press the ‘m’ key (right side) when they saw a red square and the ‘z’ (left side) when they saw a black square. A total of 64 trials were presented. The inter-stimuli interval was 500 ms. The stimulus appeared and remained on the screen until a response was made. RT was measured as the time difference between onset of the stimulus and onset of the response using the DMDX software.

B. Experimental 2 condition: The parameters were the same as those in the control 2 condition, but the black and red square appeared on either the left or right side of the screen. The experimental 2 condition was divided into two conditions: Congruent and incongruent. Congruent condition is when a red square appears on the right side and black on the left side, and if black square appears on the right and red square appears on the left side, it is incongruent condition. There were totally 64 trials and were divided into 32 trails each between congruent (hetero) and incongruent (homo) items. Diagram 3.1 shows the presentation of congruent and incongruent conditions

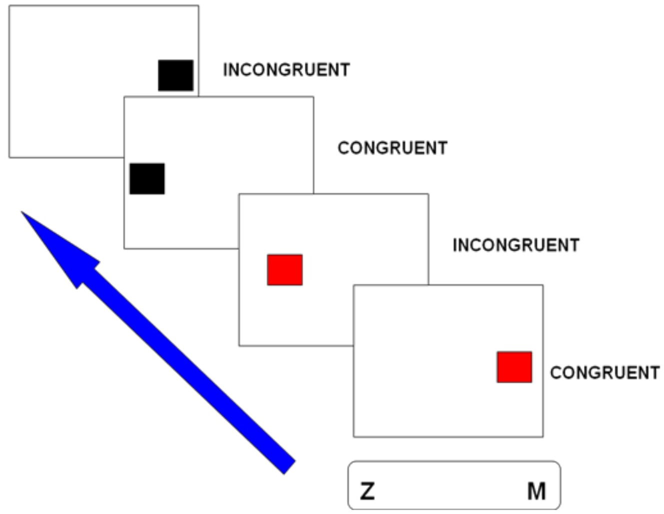

Figure 3.1: Congruent and incongruent conditions of two color condition

C. Control 4 Condition: This condition was similar to the control 2 condition, except that the stimulus was four colors (blue, brown, yellow or green). Participants were instructed to press the ‘z’ key when they saw a green or a brown square and the ‘m’ key when they saw a yellow or blue square. A total of 64 trials were run. In this condition, all the stimuli appeared in the center of the screen. This condition places greater demand on working memory for the assignment of colors to responses than did the Control 2 condition.

D. Experimental 4 Condition: In this condition, the stimuli were the same four colors which were used in control 4 conditions, but the stimuli appeared in one of the two side positions (left or right). The order of 64 trails were randomized and again divided into 2 conditions of congruent and incongruent. Figure 3.2 shows the presentation of congruent and incongruent conditions in the experiment.

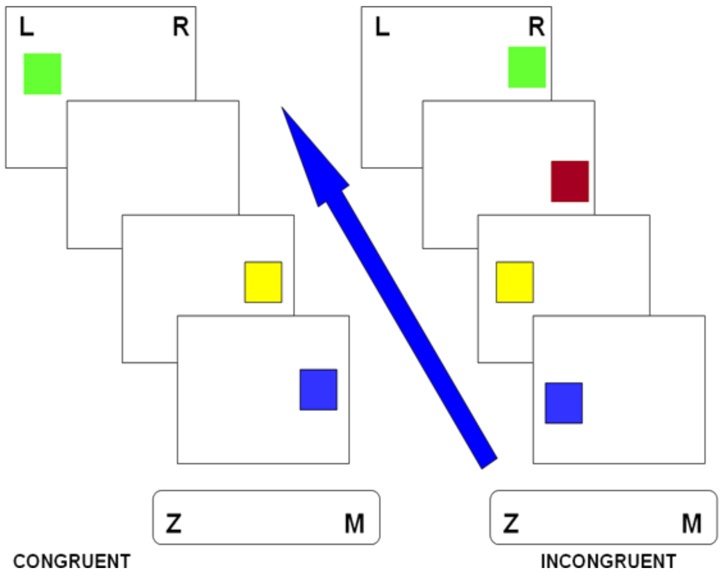

Figure 3.2: Congruent and incongruent conditions of four color condition

Task II

Task II was similar to Task I with four conditions, but in task II colored written words were used instead of blocks. This would give us some information on whether word form makes any difference in RT when compared to blocks.

Task III

Task III also contained 4 conditions, number of stimulus and response keys and colors were as in Task I and Task II. Task III was a combination of Stroop task and Simon task i.e. both spatial interference and process of automaticity were combined to see the effect of increased cognitive loading.

In this task in all the conditions the colors of the words were different from what the actual written word mean (Stroop task); for example, the word “red” appeared in black color and the word ‘black’ appeared in ‘red’ color. The participants were instructed to respond to the color of the word than the meaning of the actual written word, i.e. if the word ‘red’ appears in ‘black’ color participants were instructed to press ‘z’ key and when they saw a written ‘black’ word which appeared in ‘red’ color they were supposed to press ‘m’ key.

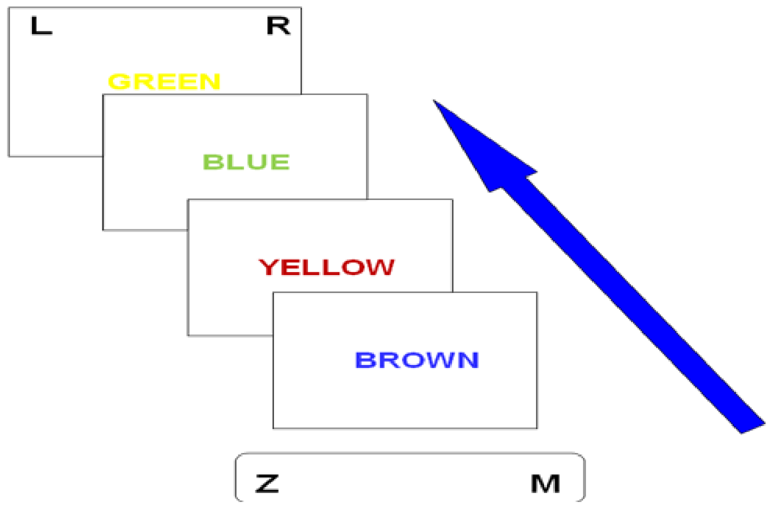

Figure 3.3: Stroop 4- color condition

This experiment is color naming rather than reading the actual word. As mentioned in previous tasks (I & II), in control 2 condition words appeared in the middle of the screen and in experimental 2 condition words appeared either on left or right side of the screen. Also, if the ‘red’ colored word appeared on the right side of the screen it is congruent condition and if it appears on the left side is incongruent condition, and it is vice versa for ‘black’ colored word. Figure 3.3 shows 4 color stroop conditionIn control 4 and experimental 4 conditions, the colors of the words appeared as given below: means the actual written word ‘green’ appeared in ‘brown’ color three times in both congruent and incongruent conditions, in ‘yellow’ color two times, and in ‘blue’ color three times. Table 3.1 shows the color combination used in task III in 4-color condition.

Table 3.1: *Total number of stimuli presented in task III in 4-color condition*

Actual word	Color of the word	Number of trials
Green	Brown	3
	Yellow	2
	Blue	3
brown	Green	2
	Blue	3
	Yellow	3
Blue	Green	3
	Yellow	3
	Brown	2
yellow	Green	3
	Brown	3
	Blue	2
Total stimulus in one condition		32

Analysis: The standard procedure to calculate Simon and Stroop was used to analyze the data as:

A. Simon Effect: RT of congruent condition was subtracted from the incongruent condition in experimental conditions to give the Simon effect. For example if the interference is longer Simon effect will be larger, that is RT of incongruent condition will be longer than congruent condition.

1) Incongruent 2 –congruent 2 gives Simon effect for two color condition
2) Incongruent 4 –congruent 4 gives Simon effect for four color condition

B. Stroop effect: In order to get Stroop effect, RT of control 2 and control 4 conditions in task III was subtracted from control 2 and control 4 conditions of Task II.

Combined effect:

3) Incongruent 2 –congruent 2 of task III gives combined effect for two color condition
4) Incongruent 4 –congruent 4 of task III gives combined effect for four color condition

CHAPTER – 4

RESULTS AND DISCUSSION

Present experiment had total of 23040 (64*12*30) trails. 1518 trails were deleted from the analysis because they were error responses or no responses. Remaining data was considered for further analysis. Mixed ANOVA was computed for within subject factors (3), color conditions (2) and other conditions (3) and between subject factors. Table 4.2 shows the mean and SD for both the groups across the three tasks for all the conditions.

Table 4.1: *Mean and SD for all the conditions of both groups*

Tasks	Conditions	Group			
		PWNS		PWS	
		Mean	SD	Mean	SD
Task I	sbcon 2	399.18	25.8	517.35	82.4
	sbcong 2	433.21	41.9	516.27	50.6
	sbincong 2	439.26	47.1	545.87	61.0
	sbcon 4	531.60	74.2	632.52	79.9
	sbcong 4	480.98	39.6	640.69	104.6
	sbincong 4	490.36	39.5	651.33	107.0
Task II	swcon 2	356.78	27.9	476.30	59.6
	swcong 2	390.51	24.2	508.83	61.3
	swincong 2	413.91	19.3	534.62	62.1
	swcon 4	452.81	34.6	551.04	85.8
	swcong 4	456.39	28.3	639.47	73.4
	swincong 4	474.85	28.2	617.71	90.0
Task III	smstcon 2	403.96	25.3	506.33	89.1
	smstcong 2	400.63	34.3	526.36	74.1
	smstincog 2	426.46	27.2	549.22	68.2
	smstcon 4	569.71	48.8	662.64	140.9
	smstcong 4	570.20	65.6	720.60	111.7
	smstincog 4	547.94	51.3	703.52	122.9

(sbcon2- Simon task 2 color condition with bocks; sb2cong- Simon task 2 color condition with bocks congruent condition; sbincong2 - Simon task 2 color condition with bocks incongruent condition; sbcon4 -Simon task 4 color condition with blocks; sbcong4 - Simon task 4 color condition with bocks congruent condition; sbincong4- Simon task 4 color condition with bocks incongruent condition; swcon2- Simon task 2 color condition with written color words; swcong2- Simon task 2 color condition with written color words congruent condition; swincong2- Simon task 2 color condition with written color words incongruent condition; swcon4- Simon task 4 color condition with written color words;

swcong4- Simon task 4 color condition with written color words congruent condition; swincong4- Simon task 4 color condition with written color words incongruent condition; smstcon2-Simon and Stroop task 2 color condition; smstcong2-Simon and Stroop task 2 color congruent condition ; smstincon2-Simon and Stroop task 2 color incongruent condition; smstcon4-Simon and Stroop task 4 color condition; smstcong4-Simon and Stroop task 4 color congruent condition; smstincong4-Simon and Stroop task 4 color incongruent condition)

Mixed ANOVA was computed for tasks (3), color conditions (2) and different conditions (3) as within subject factors and group as between subject factor. Table 4.2 shows the df, F, sig values for main effects and interaction effects.

Table 4.2: *df, F and Sig. values of tasks, color condition and different conditions (control, congruent, incongruent) between both groups*

Source	df	F	Sig.
Task	2	34.715	.000*
Task * Group	2	.196	.823
Color	1	189.845	.000*
Color * Group	1	2.338	.137
Cond	2	42.452	.000*
Cond * Group	2	16.290	.000*
Task * Color	2	20.951	.000*
Task * Color * Group	2	.409	.666
Task * Cond	4	9.942	.000*
Task * Cond * Group	4	1.780	.138
Color * Cond	2	6.805	.002*
Color * Cond * Group	2	9.774	.000*

(* $p < .00$)

Results of mixed of ANOVA showed main effect for tasks, color and for conditions (control, congruent, incongruent). Interaction effects for task * condition, condition * group, color*condition and task*color were found. No interaction effects were found for task * group and color * group. Also between subject factors showed significant difference. Boneferroni test was computed to see the pair-wise difference across tasks and conditions. Results showed a significant difference across all the tasks and conditions ($p < .05$). These results indicate that overall RT for the three tasks are different between groups. Also RT for three conditions, that is, control, incongruent and congruent, differed significantly between groups. Looking at the table 4.1 we can infer that 4 color condition showed longer RT compared to 2-color condition. As far as the control, congruent and incongruent conditions are concerned, in all the tasks incongruent condition showed longer RT compared to congruent conditions. But in task III, in 4-color condition, incongruent condition showed lesser RT (M= 547.94) compared to congruent condition (M = 570.2).

To delineate the results further, repeated measures of ANOVA was computed for each task separately to see within group and between group differences across color conditions (2 color: red, black; 4 color: brown, green, yellow & blue) and different conditions (control, congruent, incongruent conditions).

Task I

Task I used colored blocks as the experimental stimulus to investigate the cognitive processing in both groups. This task is non-linguistic in nature.

1. Within group analysis

Repeated measures ANOVA was computed for within subject factor color condition and different conditions. The following table 4.3 shows main effect and interaction effect for PWNS group.

Table 4.3: *df, F, significance value for within group comparison in task I*

Source	df	F	Sig.
Color	1	98.852	.000
Condition	2	2.098	.142
Color * Condition	2	23.318	.000

Table 4.3 shows a main effect for color condition but failed to show any difference for other conditions. In PWNS in color 2-condition congruent conditions showed longer RT in congruent condition, and incongruent was longer than control and congruent condition. In 4-color condition congruent condition showed shorter RT compared to control condition and incongruent condition showed longer RT compared to control and congruent conditions.

Table 4.4: *Main effect and interaction effect for PWS group*

Source	df	F	Sig.
Color	1	24.440	.000
Condition	2	8.330	.001
Color * Condition	2	.368	.695

Table 4.4 shows that there is a significant difference for main effect and interaction of color * condition. Results of Bonferroni showed no difference between control and congruent conditions ($p>.05$). That is, though incongruent conditions showed longer RT than congruent condition, all the other conditions showed significant difference ($p<.05$).

Performance of PWNS in Task I indicates that there was an increase in RT when the complexity was increased, that is between 2 and 4 color conditions. This shows that as the cognitive load increases there is a increase in RT. Increased RT in incongruent conditions compared to congruent condition shows there is a interference effect in PWNS group as well. In PWS group the same trend was found but the overall RT for all the conditions showed increased difficulty in performance.

2. Between group analyses

Figure 4.1 shows mean and SD for both the groups for task I across control, congruent, and incongruent conditions of both color conditions between PWS and PWNS.

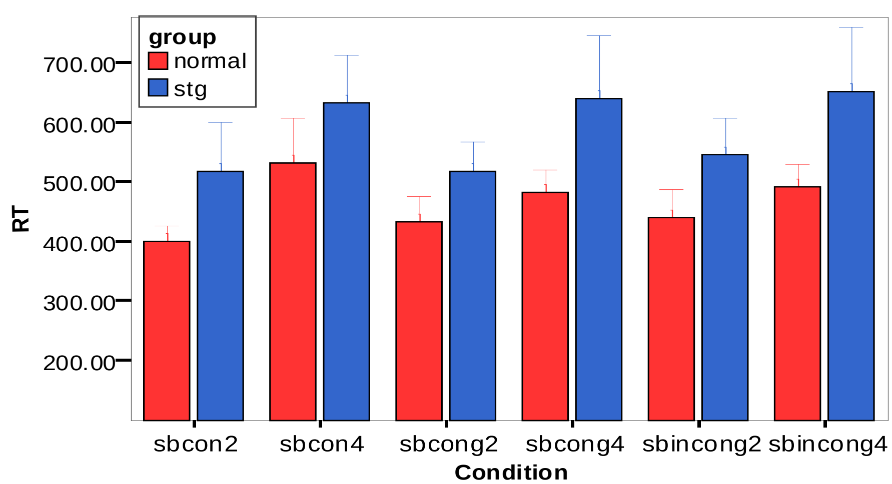

Figure 4.1: Mean & SD for different conditions in task I

Independent t test was computed to see the significance of difference between both the groups across color conditions and different conditions. Table 4.5 shows the t value, df, and p value for different conditions of task I.

Table 4.5: *t, df, sig value of between group comparison*

Conditions	t	df	Sig. (2-tailed)
sbcon2	-5.298	28	.000
sbcong2	-4.894	28	.000
sbincong2	-5.355	28	.000
sbcon4	-3.583	28	.001
sbcong4	-5.527	28	.000
sbincong4	-5.462	28	.000

From the table 4.5 and figure 4.1 it is clear that PWS group showed significantly longer RT when compared to PWNS group across all the conditions in task I. The results clearly indicate that PWS group significantly differs from PWNS group in color naming in task I. That is, the interference effect and RT for different conditions indicate longer processing time for PWS group.

Considerably more research has been done on manual reaction times, generally by having the subject press a button with a finger. The results have been conflicting. Borden, (1983) reported that PWS were slower in the execution of finger counting tasks, but not in their initation. Cross & Luper, (1983) found that voice and finger reaction times of PWS were highly correlated, but Starkweather, Franklin and Smigo (1984) did not. Wilkins, Webster and Morgan (1984) and Hurford and Webster (1985) reported that manual reaction times for PWS were faster after speech therapy than before. Such results shed some light on the inability of PWS in the execution of movements on demand in complex environments. Before execution of any movement it has to be programmed and sequenced. Using tasks which probe planning of movements would reveal the reason for delayed responses.

Working memory cost for task I

The relative effects of increasing the number of possible stimuli from two to four - referred to here as working memory costs - are assessed by subtracting RTs for two-color from four-color conditions for the groups (Bialystok, Craik, Klein & Viswanathan, 2004). That is, RT of control, congruent and incongruent 4-color condition is subtracted from control, congruent and incongruent 2- color conditions within each task.

Table 4.6: *Working cost memory for task I*

Memory Cost	PWNS		PWS		t	df	sig
	Mean	SD	Mean	SD			
sbcenter	132.42	58.19	115.1	87.40	.636	28	.530
sbcong	47.77	37.63	124.4	109.48	.329	28	.016
sbincong	51.09	29.31	105.45	109.79	-2.564	28	.075

(sbcenter - Simon block center, sbcong - Simon block congruent, sbincong - Simon block incongruent)

PWS group showed more memory cost in congruent and incongruent conditions but failed to show any significant difference ($p > .05$). In control condition PWS group showed lesser memory cost than PWNS group.

Task II

1. **Within group analysis**

Repeated measures ANOVA was computed for within subject factor color condition (2 and 4 color) and different conditions (control, congruent and incongruent). The table 4.7 below shows main effect and interaction effect for PWNS group. Results showed a main effect for both color and conditions. Interaction effect was also found to to to be statistically significant.

Table 4.7: *Within group comparison of task I for PWNS*

Source	df	F	Sig.
Color	1	232.119	.000
Condition	2	55.343	.000
Color * Condition	2	6.128	.006

Table 4.8: *Within group comparison of task II for PWS*

Source	df	F	Sig.
Color	1	41.890	.000
Condition	2	35.710	.000
Color * Condition	2	6.985	.003

Table 4.8 shows that there is a significant difference for main effect and interaction of color * condition for PWS group.

In task II congruent condition showed longer RT when compared to control condition in both groups. Also, incongruent condition showed longer RT compared to control and congruent conditions. In task II colored written words were used instead of blocks used in task I. Using a written word instead of blocks evokes the involvement of linguistic processing as well. Stimuli which were used in task II were written word ‘red’ appearing in color ‘red’. Participants’ task was to name the color of the word. Since the word color and the meaning of the color were the same this would not produce any semantic interference effect but could produce only spatial interference effect.

2. **Between group analysis**

From Fig, 4.2 it is clear that PWS showed longer RT in all the conditions compared to PWNS. 4- color conditions showed longer RT compared to 2-color condition. This indicates that as the complexity increased RT also increased for both groups. Figure 4.2 shows mean and SD for both the groups for task II across different conditions.

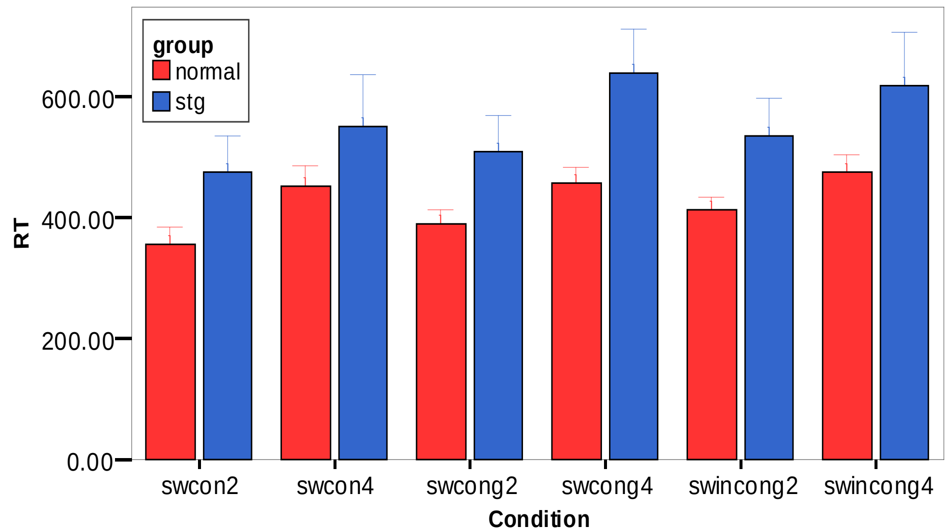

Figure 4.2: Mean & SD of different conditions in task II of PWS and PWNS.

Independent t test was computed to see the significance of the difference between both the groups across color conditions and different conditions (control, congruent and incongruent).

Table 4.9: *t, df, sig value of between group comparison*

Conditions	t	df	Sig
swcon2	-7.025	28	.000
swcong2	-6.943	28	.000
swincong2	-7.176	28	.000
swcon4	-4.108	28	.000
swcong4	-9.004	28	.000
swincong4	-5.863	28	.000

From the table 4.9 showing the t values, df and p values for different conditions of task II and figure 4.2, it is clear that PWS group showed significantly longer RT ($p < .05$) when compared to PWNS group across all the conditions in task II.

Though the task II used linguistic stimuli instead of blocks, the results showed a similar trend as in task I. Providing a linguistic stimuli would involve linguistic processing as well with the spatial interference. Both the groups performed similarly where the incongruent condition showed longer RT compared to congruent and control condition. It was expected that involvement of linguistic component would slower the processing ability of PWS compared to PWNS, but such an effect was not found in task II. It was hypothesized by many researchers that PWS are slower in their language processing than their normal peers (Kent, 1984; Postma & Kolk 1993; Conture 2001).

Memory cost for task II

The following table shows memory cost for different conditions of both the groups in task II. Table 4.10 indicates that PWS group showed more memory cost for congruent and incongruent conditions than control condition, wherein PWS group showed lesser memory cost than PWNS group. Only congruent condition showed statistically significant difference between group ($p < .05$).

Table 4.10: *mean, SD, t, df, sig value of memory cost task II*

Memory Cost	PWNS		PWS		t	df	sig
	Mean	SD	Mean	SD			
Swcenter	96.02	44.22	74.73	82.96	.877	28	.388
Swcong	65.8873	17.67972	130.6433	60.30635	-3.991	28	.000
swincong	60.9424	23.80606	83.0850	57.60304	-1.376	28	.180

(swcenter-Simon word center, swcong- Simon word congruent, swincong- Simon word incongruent)

Task III

1. **Within group analysis**

Task III involved combination of Simon and Stroop task. This considerably increases the cognitive loading which probes spatial interference as well semantic interference and automaticity of word reading for processing in order to select the correct response.

Repeated measures ANOVA was computed for within subject factor color condition and different conditions. The table 4.11 below shows main effect and interaction effect for PWNS group.

Table 4.11: *df, F, sig value of within group comparisons of PWNS*

Source	df	F	Sig.
Color	1	513.433	.000
Condition	2	.030	.970
Color * Condition	2	9.724	.001

Table 4.11 values show a significant difference in color conditions and not in other conditions (control, congruent and incongruent). Also, interaction effect was found between color and conditions. This indicates that even in task III, RT was longer in 4-color condition compared to 2 color condition.

Table 4.12 shows df, F, and sig values for color conditions and different conditions (control, congruent & incongruent) for task III between groups.

Table 4.12: *df, F, sig value for with group comparison for PWS*

Source	df	F	Sig.
Color	1	50.869	.000
Condition	2	7.182	.003
Color * Condition	2	1.956	.160

Table 4.12 shows that there is a significant difference for main effects for color and different conditions and no interaction effect found. PWS group showed a significant difference in main effect for color and different conditions.

3. Between group analysis

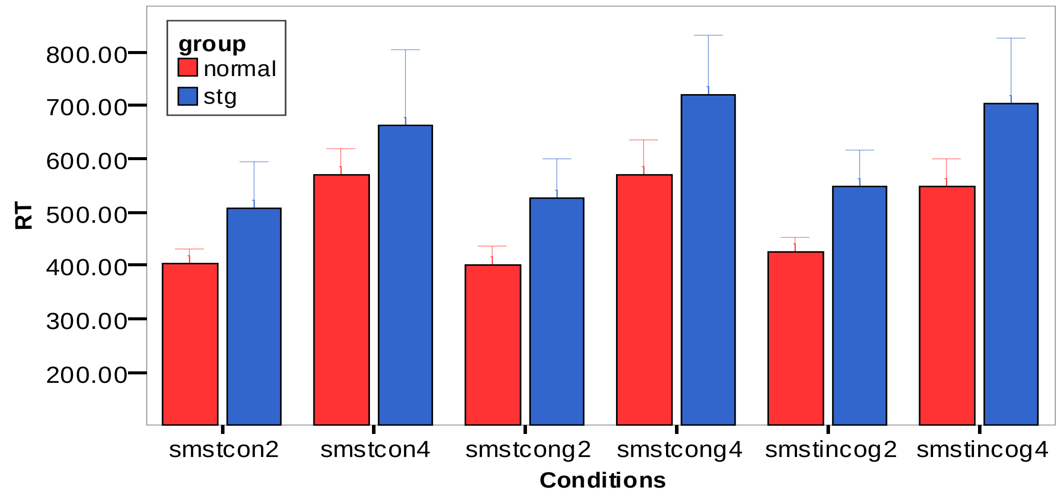

Figure 4.3: Mean and SD of different conditions in task III

Figure 4.3 indicates that PWS group showed longer RT in all the conditions compared to PWNS, 4- color conditions showed longer RT compared to 2- color condition. This indicates that as the complexity increased RT also increased for both groups.

Independent t test was computed to see the significant difference between both the groups across color conditions and different conditions. Tables 4.11 and 4.12 show the t value, df and p value for different conditions of task III for the two groups.

The results showed some interesting findings. 2-color condition showed shorter RT compared to 4 color conditions in both the groups as expected. But as far as the control, congruent and incongruent conditions are concerned; it failed to show a significant difference between groups. Also in 4-color condition, incongruent condition showed shorter RT compared to congruent condition in both the groups. It could be due to learning effect. This phenomenon is discussed later in this chapter.

Table 4.13 t, df, sig values for control, congruent and incongruent conditions of both colors between groups. Results showed a significant difference across all the conditions between groups. As the complexity increased RT also increased in both the groups. PWS and PWNS group showed longer RT in task III compared to I and task II.

Table 4.13: *t, df, sig value for between group comparison*

Conditions	t	df	Sig
smstcon2	-4.275	28	.000
smstcong2	-5.957	28	.000
smstincog2	-6.472	28	.000
smstcon4	-2.413	28	.023
smstcong4	-4.496	28	.000
smstincog4	-4.521	28	.000

Memory cost

Table 4.14: *mean, SD, t, df, sig values of memory cost for task III*

Memory Cost	PWNS		PWS		t	df	sig
	Mean	SD	Mean	SD			
comcenter	165.7461	30.46859	156.3149	106.71381	.329	28	.745
comcong	169.5697	47.37071	194.2465	102.26655	28	.404	.404
comincong	121.4738	32.62590	154.2987	104.75696	28	.256	.256

(Comcenter- combined center, comcong- combined congruent, comincong- combined incongruent)

The table 4.14 shows memory cost for both groups in task III. Memory cost was calculated subtracting RT of 2 color conditions from 4 color conditions.

From the table values it is clear that PWS group showed more memory cost in congruent and incongruent conditions than PWNS group. This indicates memory requirement is more in PWS group than PWNS group. But the difference between both groups failed to show significance in all the conditions.

Overall comparison of three tasks

In order to see the over-all performance between tasks within group, repeated measures ANOVA was computed. Results indicated a significant difference between the three tasks for both PWNS and PWS groups. ($F (2, 15) = 27.043, p <;05$); ($F (2, 15) = 12.175, p < .00$)

The table 4.15 shows pair-wise comparison computed by Bonferroni test across tasks in PWS group. It is clear from the table that task I which used blocks to investigate Simon effect was significantly different from task II which used words to investigate Simon effect. There was no significant difference between task III and Task I. But tasks II and III were statistically different.

Table 4.15: *Pair-wise comparison of three tasks of PWS group*

Between Tasks	Overall mean of Tasks	Mean Difference	sig
1 & 2	554.667	29.342	.016
1 & 3	611.450	-27.441	.199
2 & 1	554.667	-29.342	.016
2 & 3	611.450	-56.782	.001
3 & 1	554.667	27.441	.199
3 & 3	611.450	56.782	.001

Looking at the table we can infer that task I was significantly different from task II and not from III, but showed longer RT. That is RT of task III was similar to task I and task II showed longer RT compared to task I and III. It is expected that task III is supposed to produce longer RT compared to other two tasks.

Table4.16: *Pair-wise comparison of three tasks of PWNS group*

Between Tasks	Overall Mean (ms)	Mean Difference	sig
1 & 2	424.214	38.223	.009
1 & 3	486.488	-24.052	.000
2 & 1	424.214	-38.223	.009
2 & 3	486.488	-62.275	.000
3 & 1	424.214	24.052	.000
3 & 3	486.488	62.275	.000

Table 4.16 shows pair-wise comparison computed by Bonferroni test across tasks in PWNS group. The values show a significant difference between all the tasks in PWNS group. That is, the RT in the three tasks is statistically different from one another. Task III had longer RT compared to task I and task II.

A. Simon Effect

Simon effect shows the difference between congruent and incongruent conditions. The difference between RTs to congruent and incongruent stimuli (the Simon effect) reflects the efficiency of inhibitory processes. That is, the participants' task is to press the key associated with the stimulus color regardless of spatial position; therefore, smaller Simon effects reflect less inhibition cost and more efficient inhibitory processes. More Simon effect indicates that the participant showed longer RT in incongruent than congruent condition. The table 4.17 shows mean and SD for Simon effects across three tasks.

Table 4.17: *Mean and SD of Simon effect between both groups*

Simon effect	PWNS		PWS	
	Mean	SD	Mean	SD
sb2eff	6.04	21.05	29.60	30.48
sb4eff	9.37	20.37	10.64	33.74
sw2eff	23.40	24.18	25.79	33.03
sw4eff	18.45	10.25	-21.76	36.91
com2eff	25.83	31.828	22.86	32.78
comb4eff	-22.26	36.82	-17.08	37.91

Figure 4.4 shows mean and SD of Simon effect for all the three tasks across color conditions for both the groups. A negative Simon effect was found for combined Simon and Stroop 4 color condition (comb4eff) in both the groups.

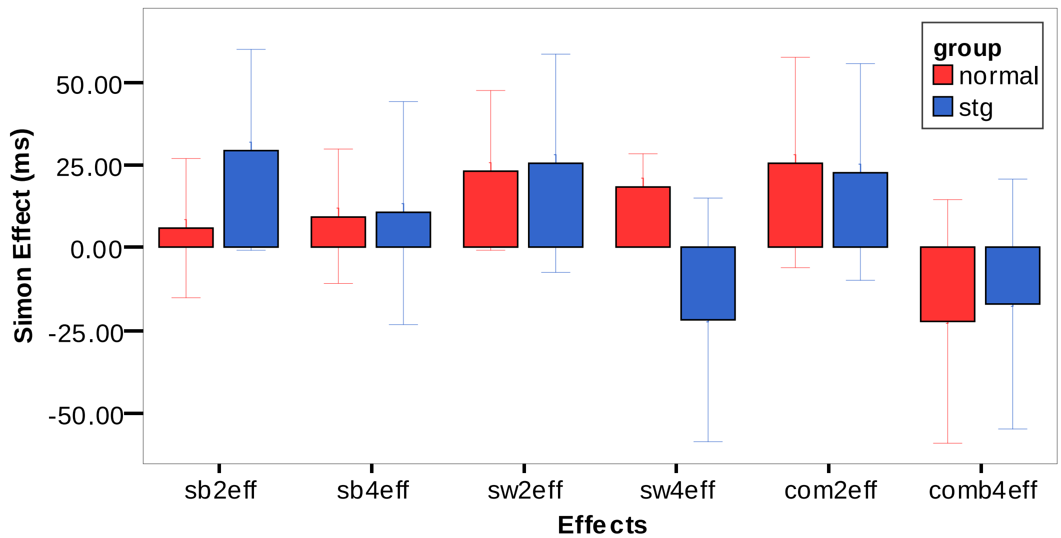

Figure 4.4: Mean and SD for Simon effects

(Sb2eff- Simon block 2 color condition effect; sb4eff Simon block 4-color condition effect; sw2eff- Simon word 2-color condition effect; sw4eff- Simon word 4-color condition effect; com2eff- combined 2-color condition effect (SMST); comb4eff- combined 4-color condition effect)

Independent t-test was computed to see the significant difference between groups for Simon effects. It revealed unequivocal results. Simon effect was greater for PWS group only in sb2 condition and all the other color conditions produced either negative effect or PWS group had lesser Simon effect compared to PWNS group.

Table 4.18 shows the t values, df, and p values for Simon effect between groups. Results in the table shows that there is significant difference in the Simon effect in block 2-color condition that is task I and Simon effect in word 4-color condition that is task II and other conditions failed to show statistically significant difference. This indicates that PWS group had longer RT (M=29.60) than PWNS (M= 6.0493). But in sw4 condition PWNS showed negative effect (M = -21.76) than PWNS group (M= 18.45). Also, in task III combined effect was negative for both the groups.

Table 4.18: *t, df, sig values for Simon effects across task and color condition between groups*

Effect	t	df	Sig
Sb2eff	-2.462	28	.020
Sb4eff	-.124	28	.902
Sw2eff	-.226	28	.823
Sw4eff	4.066	28	.000
comb2eff	.252	28	.803
Comb44eff	-.379	28	.707

In the experiment task I was presented first followed by task II and finally task III was presented. This could have led to the learning process in both the groups. Results clearly indicate that in task I Simon effect for both color conditions were significantly different between groups. And as the tasks progressed the effects started to diminish.

Increased RTs shows some deficit in information processing at the level of response selection stage. Since no other studies have been reported with respect to Simon task in PWNS, the results of this investigation could not be compared. Though the PWS group showed increased RT across all the tasks, the Simon effect failed to show such a significant difference across tasks and color condition. Results revealed significant difference in Simon effect only in sb2 $t(28) = -2.462$, $P = .020$) and sw4 $t(28) = 4.066$, $P = .000$) condition. Sb2 Simon effect clearly shows a greater Simon effect in PWS ($M = 29$ ms) compared to PWNS ($M = 6$ ms). This indicates that PWS group showed reduced ability to inhibit the spatial interference effect in selecting the target response. In sb4 and sw2 Simon effect ($m = 9, 23$ respectively) PWS group showed slightly higher Simon effect, but not statistically significant difference compared to PWNS ($M = 10, 25$). Interestingly, in task III which probed combined effect of Simon and Stroop task showed negative effects in both the groups in 4 color condition. It was expected that combining both Simon and Stroop tasks would maximize the cognitive loading thus producing greater effect and increased RT. RT of combined task seemed to be higher when compared to task I and task II in PWS and PWNS, indicating increased processing time. But Simon effect failed to produce any significant difference between groups, also showing a negative effect. This can be attributed to learning effect.

In within group comparison, PWNS group showed increased Simon effect across tasks. That is task I showed lesser Simon effect compared to task II and task III showed increased Simon effect than task I and task II. Such a trend was not found in PWS. This could be an indication that PWS group somehow differ from PWNS group in processing of information. Another important factor could be that individual variability. Inter subject variability could have masked the results.

B. Stroop Effect

Figure 4.5 shows mean and SD of Stroop effect for different color conditions of both the groups. The following figure shows that there is increased RTs for PWS in both Stroop 2-color condition and as well as Stroop 4-color condition than PWNS.

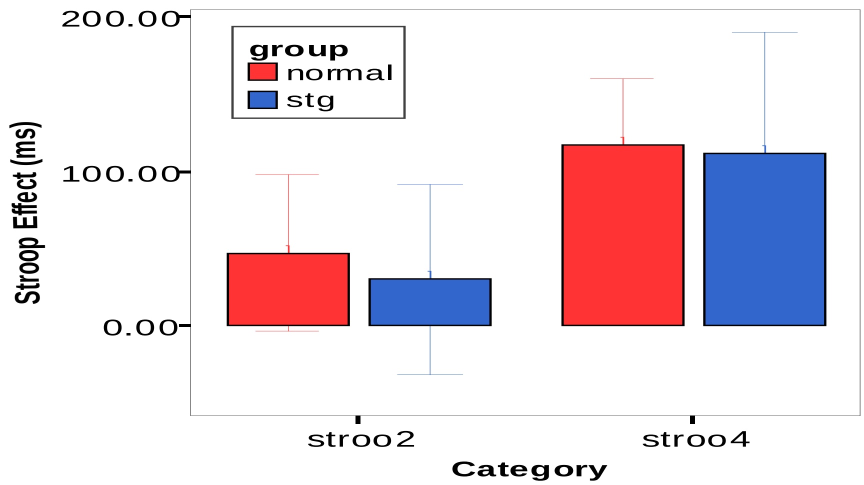

Figure 4.5: Mean and SD for Stroop effect for both color condition

Independent t-test was computed to see the significant difference between groups for Stroop effects. Table 4.19 shows the t value, df and p value for Stroop effect. Results indicate that there is no statistically significant difference for both Stroop 2 and Stroop 4 between groups. But PWNS group showed more Stroop effect than PWS group in both color conditions.

Table 4.19: *t, df, sig value for Stroop effects across color conditions between groups*

Effect	t	df	Sig
Stroop 2-color condition	.838	28	.409
Stroop 4-color condition	.230	28	.820

As far as the Stroop effect is concerned there was no statistically significant difference were found between both the groups. Results also indicated that PWS showed lesser Stroop effect compared to PWNS group. However, Stroop effect was more in 4 color condition compared to 2 color condition in PWNS (M = 47, 116 ms respectively) and PWS (M = 30, 111 ms respectively). Increased Stroop effect shows increased processing time for both groups. This result should be noted with some caution due to simplicity of method and color combinations. Also, variability between subjects would have masked the results.SD in Stroop-2 color condition in PWNS was 50ms and in PWS group it was 61 ms and in Stroop 4-color condition , PWNS showed SD of 43 ms and PWS group showed 78 ms.

Subramaniyan and Yairi (2006) reported better performance by PWS group compared to normal and high risk group. Results of their study (Subramanian & Yairi, 2006) indicated that reaction time was greater for conflict condition, that is, when the ‘blue’ word is seen in ‘green’ color. Unexpectedly, the PWS group had shorter RTs when compared to its control group and the high risk group. Specifically, in the conflict condition, the PWS group exhibited shortest RTs. When the ratios of the conflict- to-congruent reaction time were calculated, the PWS group yielded a ratio of 1.16; it was 1.14 for the high risk group. The ratios for the control groups were 1.22 and 1.26 respectively. Thus, the conflict condition did not affect the reaction time for the experimental groups to the extent it did for the control group. Accuracy values were 100% for all groups in the congruent condition. In fact, accuracy was high for all groups in all other conditions although still lowest for the conflict condition. Based on these results investigators speculated that when placed under external interferences, people who stutter may use different speech motor control (including stages of processing, planning and production) strategies that result in lower reaction time for this group.

Present study showed longer RT in incongruent conditions than congruent conditions in Stroop task. This indicates some processing delay in incongruent condition. But Stroop effect showed no statistically significant difference between groups.

But the procedure, method, stimuli were entirely different between these two studies. It is not clear whether to accept or reject the notion that cognitive ability may be deficient in PWS group. Further studies are warranted in the same line which utilizes more complex Stroop tasks like semantic variation, priming on a larger population for this.

Relation of Simon and Stroop to Stuttering and language processing

Investigating basic processes help us in understanding the role of cognition/information processes in language processing. Simon task used spatial interference as a variable and in Stroop task automatic processing is a variable that were supposed to be inhibited in order to select a correct response. Though these tasks are not directly tapping the language processing, it gives valuable insight into information processing in PWS.

Priming paradigms are mainly used in psycholinguistics to investigate facilitatory or inhibitory processes in language processing. Phonological and semantic encoding is at mental representation level. Investigations which used priming paradigm to probe phonological encoding and semantic encoding also showed longer SRT in CWS/PWS group (Melnick, Conture & Ohde, 2003; Burger & Wijnen, 1999; Wijnen & Boers, 1994). However, they failed to provide any conclusive evidence that deficit in processing ability contribute to stuttering blocks. These investigations were of linguistic nature and involved complex method. This clearly indicates that further investigations are warranted in the same line which could probe information ability of PWS/CWS.

Present study utilized Stroop task to see the performance difference between PWS and PWNS. Apart from automatic processing like word reading even semantic interference also play a role in selecting target response. That is presenting a word “BROWN” in “BLUE” color would inhibit the correct response selection like in priming task. This in turn might increase the RT. As mentioned earlier there was no significant difference between both groups and for both color conditions. This result could be due to the fact that only 2 and 4- colors were used in the present experiment. One more reason may be that the same colors were used across all the tasks. Using many different colors and trials would help us better understand the automatic processing or semantic interference in Stroop task.

Since many variables are involved in understanding language processing, it is mandatory to understand about various levels of cognition in depth before we can come to some conclusion.

CHAPTER – 5

SUMMARY AND CONCLUSION

Present study aimed at investigating cognitive processes in PWS and PWNS in order to see whether PWS differs from PWNS. Two paradigms Simon and Stroop tasks were used to probe information processing on of the important component of cognition. The experiment had three tasks. Task I probed Simon effect using blocks, task II used colored words instead of blocks to probe Simon effect and task III probed combined Stroop and Simon effect using colored words. Each task had 2 and 4 color conditions and each color conditions had control, congruent and incongruent conditions.

Investigating Simon effect in both groups would reveal possible differences between PWS and PWNS, if any, with respect to response selection by inhibiting spatial interferences. Stroop effect would reveal whether PWS and PWNS differ in their ability to inhibit automatic processing of word reading in a color naming task. Finally, the effects of combination of both Stroop and Simon paradigms in both groups would necessarily increases the cognitive loading, and comparing both groups would reveal processing ability.

Simon task and effect

In summary, findings from task which used blocks to probe Simon effect showed increased RT for PWS compared to PWNS in 2 and 4 color conditions across control, congruent and incongruent conditions. However, Simon effect showed a significant difference in 2-color condition where PWS group showed more Simon effect. This indicates some deficits in inhibitory processes in PWS. But 4-color condition failed to show such a difference between groups, also the effect was reduced in PWS. Memory cost indicated that PWS showed more memory cost compared to PWNS in congruent and incongruent conditions. This indicates more processing time required by PWS group compared to PWNS.

In task II which used colored words instead of color blocks, PWS showed longer RT compared to PWNS in 2 and 4-coor conditions across control, congruent and incongruent conditions. Simon effect showed a scattered result, that is, in 2-color condition PWS showed slightly more Simon effect, but a negative effect in 4-color condition. Memory cost in task II also showed a similar result as task I. PWS showed more memory cost in congruent and incongruent conditions compared to PWNS.

The results of the present study converge to indicate an inconclusive evidence to prove any inadequacy of cognitive processes in PWS group or failed to show any difference in terms of their inhibitory processes.

Stroop effect

Task III probed Stroop effect using colored words. Though there was a difference between the two groups in Stroop effect, that is, PWS group showed more Stroop effect compared to PWNS in 2 and 4-color conditions, it was non-significant. This indicates some deficit in inhibiting interference caused by automaticity that is word reading in PWS compared to PWNS

Combined effect

Task III which probed the combined effect of Simon and Stroop showed longer RT in PWS compared to PWNS in 2 and 4-color condition across control, congruent, and incongruent conditions. In 2-color condition PWS showed marginally less effect than PWNS and in 4-four color condition both groups showed a negative effect. This negative effect may be due to learning effect. In task III memory cost effect failed to show any significant difference between both groups in all conditions. But PWS showed more memory cost effect in congruent and incongruent conditions than PWNS.

To conclude, the results of the present experiment do not completely prove or agree with the notion that PWS group might have some deficit in their cognitive processing with respect to information processing. At the same time the results of this experiment should be considered with some caution due to its simple method and materials involved. With the current knowledge and experimental methodology it is not possible to say that PWS group does not exhibit any cognitive deficits.

In order to understand the disorder “stuttering” it is important to examine not any one aspect of stuttering but rather combination of aspects such as inventing a method which probes the effect of Simon or Stroop task on neurophysiological aspect, motoric aspect, behavioral aspect which would reveal some more information about language processing, cognition and stuttering.

Implications of the Study:

1. The study will through light on one of the basic cognitive process that is response selection ability in PWS and interms of theoretical understanding of PWS compared to PWNS. This might help us categorizing PWS, based on their cognitive ability.

Limitations and Future directions

a. Present study used finger press as the mode of response for both Simon and Stroop task. In Stroop task measuring voice reaction time would have yielded better understanding of the nature of the problem. Also using variations of Stroop tasks would help us in probing language and cognition in PWS.

b. Less number of color modifications was used in Stroop task. Using more color combinations would decrease practice effect as well as would give better understanding of the aspects of cognition.

c. Participants were not categorized according to the severity of the problem. By categorizing the PWS based on the severity of stuttering would help us in understanding whether cognitive ability plays any role in severity of stuttering.

d. Less number of participants participated in the study. Including more number of participants, both male and female, of various age groups would help us in categorizing PWS/CWS based on their cognitive ability.

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