Behavioral and Electrophysiological correlates (N400) of lexical and phonological access in children with stuttering

by Santhosh M

Part A

1.0 **Title of the project:** Behavioral and Electrophysiological correlates (N400) of lexical and phonological access in children with stuttering

Area of research: speech, language and hearing

1.1 Principal Investigator : Dr. Santosh M

1.2 Co-Investigator: Dr. Sandeep M

1.3 Collaborating Institution: Nil

1.4 Total Grants required: 5,08,000

1.5 Duration of the project: One Year

2.0 Project summary:

The purpose of this proposal is to investigate lexical and phonological access in children with stuttering. Primed lexical decision task to investigate lexical access and rhyme judgment task to investigate phonological access will be used. The dependent variables will be include behavioral (reaction time and accuracy of responses) and electrophysiological (N400) measures. The results of this study will highlight on neural processing of lexical and phonological access in children with stuttering. Such a research will add on to existing literature on the relationship between stuttering and linguistic factors in children with stuttering.

3.0 Introduction

3.1 Definition of the problem

Multiple studies report that there is relationship between stuttering and different linguistic factors. Further, few studies have also suggested that stuttering is caused by disruption in the linguistic processes such as lexical retrieval, syntactic encoding, and phonological encoding. However, large majority of these studies are done using behavioral measures. There is limited evidence with objective measures like Event related potentials (ERPs) and available evidences with ERPs suggest atypical neural processing during lexical and syntactic encoding in persons with stuttering. However, much of these studies are done with adults. Stuttering is a developmental disorder of speech. Hence, studies with children are indeed essential for understanding the role of linguistic factors that may contribute to the etiology of stuttering. If a reported difference between individual with and without stuttering cannot be replicated with children who are closer to the onset of the disorder, then it would seem unlikely that any limitations observed in the stuttering adults were already present during early childhood and may have contributed to the development of stuttering. Hence, first objective of the present study is to compare the lexical access (through behavioral and ERP measures) between children with and without stuttering. The second objective is to compare phonological access between children with and without stuttering.

3.2 Objectives

1. To investigate whether behavioral and neural basis of lexical access vary in children with stuttering (CWS) and children with no stuttering (CWNS). Lexical access will be investigated using cross-modal priming task. For this objective,

   Lexical access will be evaluated using two dependent measures:

   i) Behavioral measures which will include reaction time and accuracy scores
   ii) Electrophysiological measures will include N400 responses

2. To investigate whether behavioral and neural basis of phonological access vary in children with stuttering (CWS) and children with no stuttering (CWNS). Phonological access will be investigated using rhyme judgment task. For this objective,

   Phonological access will be evaluated using two dependent measures:

   iii) Behavioral measures which will include reaction time and accuracy scores
   iv) Electrophysiological measures will include N400 responses

3.3 Review of status of research and develop in the project

Research on lexical retrieval (Arunkumar & Yeshoda, 2006; Hartfield & Conture, 2006; Hennessey, Nang, & Beilby, 2008; Packman, Onslow, Coombes & Goodwin, 2001; Pellowski & Conture, 2005; Newman & Ratner, 2007; Santosh & Arunkumar, 2006), syntactic encoding (Anderson & Conture, 2004; Tsiamtsiouris & Cairns, 2009), and phonological encoding (Melnick, Conture & Ohde, 2003; Vincent, Grela & Gilbert, 2012) report that children and adults with stuttering have longer reaction time for these processes compared to controlled normal population. However, majority of these investigations on the linguistic factors/process in stuttering are done with behavioral measures. There is limited evidence about the neural evidence for lexical access (through ERPs) in children and adults who stutter. Evidence from ERP studies suggest that AWS and CWS have atypical neural processing during the lexical and syntactic encoding (Weber-Fox, 2001; Cuadrado & Weber-Fox, 2003; Weber-Fox, Spencer, Spruill III, Smith, 2004; Weber-Fox & Hampton, 2008; Weber-Fox et al., 2008; Weber-Fox et al., 2013; Usler & Weber-Fox, 2015).

3.4 International and national status

Linguistic deficits in stuttering

Linguistic variables associated with specific locations of stuttering have been studied since Brown (1938). These linguistic variables include syntactic, lexical, phonological and morphological structure of words. Brown (1945) found occurrence of stuttering due to four main linguistic factors: word length i.e., number of syllables in the word, word type: grammatical class of the word i.e., content or function words, word position i.e., initial position of sentence or clause and the phoneme from which the word starts i.e., word starting with consonant or vowel. Hannah and Gardner (1968) and Wells (1979) analyzed the spontaneous speech samples of adults who stuttered on sentences and they reported that syntactic position as well as syntactic complexity had an effect on frequency of stuttering. The results of these studies highlight the influence of syntactic factors on the frequency of stuttering. There are number of studies which report that syntactic complexity increases the dysfluencies in children's speech (Bernstein Ratner & Sih, 1987; Weiss & Zebrowski, 1992). Marshall (2005), to study the effect of morphology on stuttering in English, analyzed the spontaneous speech samples of 16 males with stuttering in the age group of 16 to 47 years. From the analyzed speech samples the words were classified as having simple phonology, complex phonology and words with uninflected and inflected morphology. The results revealed that stuttering rates were not associated with phonological complexity as well as morphology. There are no much studies to provide information with respect to relationship between morphology and stuttering.

Other authors also studied the effect of additional linguistic factors which demonstrate their strong influence on the occurrence of stuttering events. Some of them are utterance length and syntactic complexity (Brundage & Ratner, 1989), phonetic complexity (Geetha, 1978) and word type (Bloodstein & Gantwerk, 1967; Helmreich & Bloodstein, 1973). Stuttering is more likely to occur on longer words or multisyllabic words compared to short ones (Brown, 1945; Williams, Silverman & Kools, 1969). Also many authors have found that occurrence of dysfluency is generally on consonants than vowels (Brown, 1938, 1945; Hahn, 1942; Hejna, 1955; Quarrington et al., 1962; Geetha, 1978).

The effect of word position on stuttering is studied by many authors. It was found that the frequency of stuttering is more at beginning of the sentence or a clause compared to other positions (Conway & Quarrington, 1963; Brown, 1938; Griggs & Still, 1979; Bernstein, 1981; Wingate, 1979; Soderberg, 1967). Jayaram (1984) studied the distribution of stuttering in sentence with respect to sentence length and clause position, and results showed that occurrence of stuttering was always at the beginning of the clause irrespective of sentence length and clause position. The results suggested that breakdown in the speech occurs due to demands on motor planning of speech which occurs particularly at the beginning of sentences. Another study by Koopmans, Slis and Rietveld (1992), also found that stuttering occurrence was high at the initiation of the clause and dysfluency occurred on function word in first and second word position than on lexical words, whereas lexical words were stuttered at third word position, this was attributed to speech planning process where function words required decision making.

Lexical factors that influence stuttering are word frequency, word class/word type. Previous research evidences reveal that occurrence of stuttering is high on low frequency words compared to high frequency words (Hejna, 1955; Newman & Ratner, 2007; Soderberg, 1966). The word class is another major factor which is studied by many authors and the results are conflicting. Some authors found that stuttering occurs mainly on content words (Jayaram, 1981; Dayalu, 2002) and other authors found that stuttering occurs on function words rather than content words (Griggs & Hall, 1979). Howell, Au-Yeung and Sackin (1999), analyzed the spontaneous speech of people who stutter and people who do not stutter in the age group from 2 to 40years to find the relationship between dysfluency of function and content words. Results revealed that people without stuttering had higher occurrence of disfluency on function words whereas in people with stuttering the occurrence of dysfluency on content & function words changed over age groups. There was higher percentage of dysfluency on function words in younger age group with stuttering and as their age increased the dysfluencies on function words gradually decreased. This study concludes that due to incomplete planning of content words, adults with stuttering have high percentage of dysfluency on these words.

Stuttering and lexical access

Wingate (1988) suggested that persons with stuttering exhibit problems in retrieving words which occurs in the third stage in Levelt's model of lexical retrieval, hence they have difficulty maintaining fluent speech. Limited research has been conducted on children and adults with stuttering to investigate whether these individuals have difficulty in lexical retrieval. This is investigated by either lexical decision task or lexical naming task using different priming paradigm.

Arunkumar and Yeshoda (2006) compared individuals with stuttering and individuals with no stuttering using lexical decision task and results revealed that they had longer reaction time compared to individuals with no stuttering and also reaction time increased as the word length increased in individuals with stuttering. Another study by Santosh and Arunkumar (2006), investigated the lexical access using semantic priming task in persons with stuttering and persons with no stuttering. Results revealed stutterers had longer speech reaction time across all 3 priming condition compared to persons without stuttering. Both groups had shorter speech reaction time for related priming condition compared to other two primes. Newman and Ratner (2007), studied the role of lexical factors-word frequency, neighborhood density and neighborhood frequency on confrontation naming accuracy, reaction time and stuttering episodes in 25 adults who stutter and 25 adults who do not stutter who were matched for age, gender and education level. The results revealed that adults who stutter had slower reaction time and less naming accuracy compared to adults who do not stutter. There was effect of word frequency on stuttering rate, but the other two lexical factors-neighborhood density and neighborhood frequency did not have any effect on stuttering rate in adults who stutter. Hence the authors concluded that adults who stutter have impairment in lexical retrieval which is at the level of phonological representation.

Hennessey, Nang, and Beilby (2008), studied linguistic encoding deficits in adults who stutter and adults who do not stutter. Auditory priming was used in picture naming which included four priming conditions-semantically related, phonologically related,

unrelated and no prime. Also word versus non word comparison in simple reaction time and choice reaction time was done. Results of picture naming revealed that, there was no significant difference in mean reaction time between the two groups. Both groups had slower naming reaction time, when auditory prime was semantically related to target picture compared to other three priming conditions. This was supported by semantic inhibition effect which has caused slower reaction when prime was semantically related. Results for simple verbal reaction time also revealed no significant difference between the two groups for word verses non words, where in choice reaction time persons with stuttering were slower compared to persons with no stuttering. Packman, Onslow, Coombes and Goodwin (2001), tested the prediction that for stuttering to occur, lexical retrieval is one of the factors. They investigated this in reading task which does not require any lexical retrieval; the task was reading aloud a Standard English passage and also a passage with non words, in three adults who stutter. The results showed that stuttering was present even in non-words in all 3 subjects and hence the authors conclude that stuttering can occur even in the absence of lexical retrieval. This study contradicts the above studies suggesting that lexical retrieval is the major factor. A recent study by Furness and Ward (2012) investigated lexical access, story re-telling and sequencing skills in eight adults who clutter in comparison with adults who do not clutter. Lexical access was assessed through three subtests: naming on description, category naming and semantic and phonological word generation and response time was measured. Sequencing skill and story recall was used to analyze the maze behaviors. The results revealed that adults who clutter were slower in lexical access tasks and also there were more maze behaviors in sequencing skills compared to control group, but there was no difference between the groups in story retelling task.

Few researchers have also investigated lexical access in children who stutter. Pellowski and Conture (2005) compared lexical priming between children who stutter and children who do not stutter. Results showed that children who do not stutter had faster and shorter lower speech reaction time in semantically related prime condition followed by no-prime condition, where as children who stutter had slow and longer reaction in both priming conditions Hence, this study suggests that children who stutter have difficulties with lexical encoding, which may influence stuttering. Hartfield and Conture (2006) investigated the effect of perceptual and conceptual properties of words in children who stutter and children who do not stutter in the age range of 3-5 years. This was investigated in picture naming task which was associated with 4 auditory lexical priming conditions-neutral, physical, functional, and categorically related speech reaction time and accuracy scores were measured. Results indicated that children who stutter took more speech reaction time in all priming conditions compared to children who do not stutter and children who stutter had faster naming latencies in functional related prime condition compared to physical related prime condition. Results indicated that lexical retrieval was influenced by conceptual/functional than perceptual aspects in children who stutter. Savage and Howell (2008), investigated the lexical priming on content and function words in children who stutter and children who do not stutter in the age group of 3 to 9 years. Children were asked to repeat the auditory prime presented followed by description of action or naming. Speech initiation time, the effect of priming on content and function words and dysfluency on prime type were analyzed.

Also comparison was done between the two groups (CWS and CWNS) for these parameters. The results revealed that effect of priming was greater in children who stutter compared children who do not stutter. There was no significant difference

between the two groups for speech initiation time and prime type. Children who stutter had fewer dysfluency on function words after content word primes than after function word primes.

Event Related Potentials in stuttering

Limited studies have been carried out using ERP and FMRI to compare the lexical access in adults who stutter and adults who do not stutter using priming tasks. Weber-Fox (2001) investigated the role of neurolinguistic factors in stuttering using Event-related potentials in nine adults who stutter and control group in the age range of 17 to 34 years. Participants were asked to read sentences silently which were presented on the computer screen and had to respond by pressing the button to judge whether sentence made any sense or not. ERP's elicited for adults who stutter for closed-class, open-class and semantic anomalies were characterized by reduced negative amplitude compared to the control group. Results showed that there were alterations in linguistic processing for adults who stutter were related to neural functions that are common to word classes and perhaps involve shared, underlying processes for lexical access. Cuadrado & Weber-Fox (2003) studied the syntactic processing using the behavioral and ERPs while the IWS and NS made judgments about the subject-verb agreement violations in simple and more syntactically complex sentences. The behavioral responses were obtained in both off-line and online tasks. The judgment accuracy for IWS was lower than the NS more so for syntactically more complex sentences. Further, amplitudes of the P600 responses for IWS were reduced when compared to NS. Weber-Fox, Spencer, Spruill III, Smith (2004) investigated the phonological processing in AWS. They recorded behavioral and ERPs from AWS and NS while the participants did a phonological rhyme judgment task. Although RTs, accuracy of responses and ERPs were similar between AWS and NS, topographic pattern for ERPs were different between two groups of individuals. Weber-Fox & Hampton (2008) studied neural processing of semantic and syntactic constraints as indexed by N400 and P600 responses in AWS and AWNS. They reported significantly differences in AWS when compared to AWNS. In Weber-Fox et al. (2008) study, ERPs were recorded while CWS and CWNS did a visual rhyming task. Results suggested N400 responses with respect to phonological rehearsal and target word anticipation was atypical in CWS. Further, there was also atypical processing with hemispheric contribution towards the linguistic integration stage of processing. Weber-Fox et al. (2013) studied CWS and CWNS while the participants listened to sentences which had either semantically or syntactic (phrase structure) violations. There were differences in both the N400 and P600 amplitudes for both semantic and syntactic violations. Usler & Weber-Fox (2015) studied neural processing of syntactic and semantic structures in, persistent, and recovered 6-7 year old CWS. Their responses were also compared to age and gender matched normal children. ERPs were recorded while these children listened to sentences which had semantic and syntactic violations in English and Jabberwocky sentences. Results suggested neural processing of syntactic structures may be less well developed in 6-7 year old children with persistent development stuttering. To summarize, limited evidence is available from ERP studies which suggests atypical neural processing during lexical access in persons with stuttering. However, all these studies are from one research group and English language. There are no replication studies in other languages. Hence, further studies are necessary.

3.5 Importance of proposed project in the context of current status

Present study will investigate lexical and phonological access in children with stuttering using ERPs. The results of this study will provide the neural evidence of lexical and phonological processing in children with stuttering. Thus, the first aim of the present study is to compare the lexical access using cross-modal priming paradigm in Children with and without stuttering. The second aim is to compare the phonological access using rhyme judgment task.

4.0 Work Plan

Two related but separate experiments will be conducted. In the first experiment behavioral and electrophysiological correlates of lexical access will be compared between children with and without stuttering. Primed lexical decision task will be used for both behavioral and event related potentials. Primed lexical decision task has been used to assess lexical semantic organization (Blumstein, Milberg & Shrier, 1982). In the second experiment behavioral and electrophysiological correlates of phonological access will be compared between children with and without stuttering using rhyme judgment task.

Experiment I

Participants

Two groups of children will be recruited for experiment 1. Group I will consists of 20 children with stuttering in the age range of 5 – 9 years. Group II will comprise of 20 children without stuttering in the same age range. Participants in both the groups will be native speakers of Kannada. For group I participants, stuttering severity will be determined with the Stuttering Severity Instrument-Fourth Edition (SSI-4; Riley, 2009). Inclusion criteria will include (a) pure tone behavioral hearing thresholds at or below 20 dB HL for all octave frequencies from 250 to 8000 Hz, (b) (c) no speech or language problems, (d) no known neurological or psychological problems or learning disabilities, and (e) not taking any medications that may have possible effects on sensory or motor systems. Participation of the participants in the study will be voluntary and participants will be enrolled only after their parent's consent.

Stimuli selection

The task will be cross-modal *primed lexical decision task*. For this task 250 word pairs in Kannada will be used. The stimuli will include pair of words, the first word being the prime and second word being the target. The prime will be presented auditorily and target will be shown in the form of pictures. Out of 150 word pairs, in each condition 40 word pairs will have prime and target which are semantically related, 40 semantically unrelated and 70 no prime words.

Procedure

The presentation of word pairs will be programmed on E-prime software. A practice block of 12 prime-target trials also comprising of semantically related, unrelated and no prime words will be designed to familiarize the participants with the task. Audio-recorded primes will be played through insert ear phones, where as the target pictures will be displayed at the centre of the computer monitor. Pictures will be displayed i on a white background. The prime will be played following by an inter-stimulus interval of 250 milliseconds, after which the target word will be displayed for duration of 2000 milliseconds. The children will be given a duration of 4000 milliseconds to name the picture. If the participant fails to respond within this duration, the response will be considered as error.

Behavioral responses

Reaction time and accuracy of responses will be measured. The reaction time will be computed from the offset of the stimulus to the onset of response. For the primed lexical decision task, the mean reaction time for prime and target pairs which are semantically related, unrelated and no prime words will be extracted. Further, number of correct responses for recognition, across the three conditions i.e. semantically related, semantically unrelated, no prime target words will be computed. The performance of group I and group II participants will be compared in order to see if there is any difference in lexical access between these two groups.

ERP recording

To prevent the practice effect, ERP recording will be done after a gap of one we from the behavioral task. The same stimuli will be considered for the ERP tasks. The cortical event related potentials will be recorded using Co umedics Neuroscan instrument with SynAmps^2 amplifier. The participants will be seated mfortably on a reclining chair. The event related potentials will be recorded using Quick Cap consisting of 64 sintered silver ch ride electrodes from18 electrode sites of international 10-10 system: FPz, Fz,FP1, FP2, FCz, Cz, CPz, Pz, F3, F4, C3, C4, C5, C6, T7, T8, P3 & P4 . Linked mastoid will be used as a reference/ active electrode. An electrode site between FPz and Fz will be us d as ground electrode. The electrode impedance will have impedance less than 5kΩ. A blunt needle will be used to clean the electrode site. Quick Gel™ filled up in the syringe will be used as conduction gel to bridge the scalp with the electrode surface. A continuous EEG data will be recorded and digitized at 1000 Hz. The data will be low pass filtered at 100 Hz, and high passing DC. The time window of 1500 ms with a pre stimu s interval of 200 ms will be considered for online averaging of target stimulus. The total duration of the testing would be around one hour and 30 minutes per participant. The proposed setting with respect to stimulus parameters and recording parameters is mentioned below.

Stimuli Parameters	
Stimuli	150 randomized word pairs (semantically related, unrelated and no prime word)
Transducer	ER 3A Insert receiver/ binaural
Interstimulus interval	1.5 s

Polarity	Alternating
No of recording	2
Recording parameters	
Filter setting	DC-100 Hz
Recording Time window	1500 ms (including 200 ms pre-stimulus baseline)
Notch filter	Off
Electrode impedance	< 5k ohms

Offline analysis of ERP waveforms. The continuous EEG waveform will be DC offset corrected with a polynomial order of two to decrease the drift in the waveforms. The DC corrected waveforms will be band pass filtered at 0.1-30 Hz. The continuous filtered EEG waveform will be epoched from -100 to 1500 msec and baseline corrected. Finally the epoched files will be averaged to obtain different waveforms for words and non-words. N400 an ERP which signify the semantic processing in individuals brain waves will be considered for further analysis.

Analysis of results

a) Comparision of behavioral (reaction time and accuracy scores) responses between children with stuttering and children with no stuttering.
b) Comparison of N400 responses between children with stuttering and children with no stuttering.

Experiment II

Participants

Same group of participants will be included in this experiment also.

Stimuli selection

The task will be *rhyme judgment task*. For this task, 200 word pairs in Kannada will be used. The first set of 100 words will comprise of pair of words, where both the words rhyme, the second set of 100 words will comprise of pair words where they don't rhyme.

Procedure

The presentation of word pairs will be programmed on E-prime software. A practice block of 12 trials will be designed separately to familiarize the participants with the task. Word pairs will be presented auditory and participants will be given a duration of 4000 milliseconds to respond. The task for the participants will be to judge whether word pairs rhyme or not. If the participant fails to respond within this duration the response will be considered as error.

ERP recording

ERP recording protocol will be similar to experiment 1.

Analysis of results

a) Comparison of behavioral (reaction time and accuracy scores) responses between children with stuttering and children with no stuttering.
b) Comparison of N400 responses between children with stuttering and children with no stuttering.

6.0 **Utilization of the results of the study-**The results of the present study would enable understanding the lexical access and phonological access in persons with stuttering, also will give inputs on the integrity of phonological input lexicon.

Behavioral and Electrophysiological correlates (N400) of lexical and phonological access in children with stuttering

ORIGINALITY REPORT

18%	10%	16%	7%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	aiishmysore.in Internet Source	5%
2	Submitted to All India Institute of Speech & Hearing Student Paper	2%
3	www.let.uu.nl Internet Source	1%
4	Tsiamtsiouris, Jim Cairns, Helen Smith. "Effects of syntactic complexity and sentence-structure priming on speech initiation time in adults w", Journal of Speech, Language, and Hearing, Dec 2009 Issue Publication	1%
5	Ann Packman, Mark Onslow, Tanya Coombes. "Stuttering and lexical retrieval", Clinical Linguistics & Phonetics, 9/1/2001 Publication	1%
6	Weber-Fox, Christine, Amanda Hampton Wray, and Hayley Arnold. "Early childhood stuttering and electrophysiological indices of	1%

language processing", Journal of Fluency Disorders, 2013.
Publication

---

7 Choo, Ai Leen, Evamarie Burnham, Kristin Hicks, and Soo-Eun Chang. "Dissociations among linguistic, cognitive, and auditory-motor neuroanatomical domains in children who stutter", Journal of Communication Disorders, 2016. 1%
Publication

---

8 Mahesh, Sangeetha and Geetha, Y. V.. "Phonetic Context in Disfluencies of Children with Stuttering", Language in India, 2013. 1%
Publication

---

9 Submitted to University of Sheffield 1%
Student Paper

---

10 Byrd, Courtney T., Megann McGill, and Evan Usler. "Nonword repetition and phoneme elision in adults who do and do not stutter: Vocal versus nonvocal performance differences", Journal of Fluency Disorders, 2015. 1%
Publication

---

11 Hennessey, N.W.. "Speeded verbal responding in adults who stutter: Are there deficits in linguistic encoding?", Journal of Fluency Disorders, 200809 1%
Publication

12	Internet Source	1%
13	Vincent, I.. "Phonological priming in adults who stutter", Journal of Fluency Disorders, 201206 Publication	<1%
14	Bretherton-Furness, Jessica, and David Ward. "Lexical access, story re-telling and sequencing skills in adults who clutter and those who do not", Journal of Fluency Disorders, 2012. Publication	<1%
15	Juste, Fabiola Staroble, Fernanda Chiarion Sassi, and Claudia Regina Furquim de Andrade. "Exchange of disfluency with age from function to content words in Brazilian Portuguese speakers who do and do not stutter", Clinical Linguistics & Phonetics, 2012. Publication	<1%
16	Daliri, Ayoub, and Ludo Max. "Modulation of auditory processing during speech movement planning is limited in adults who stutter", Brain and Language, 2015. Publication	<1%
17	Submitted to University of Houston System Student Paper	<1%
18	Submitted to 74751 Student Paper	

<1%

19 Jayaram, M.. "Phonetic influences on stuttering in monolingual and bilingual stutterers", Journal of Communication Disorders, 198307
Publication
<1%

20 Devaraju, Dhatri S.; Vrinda R.; Shanbal, Jayashree C.; Mamatha N. M. and Gopi Sankar R.. "LEXICAL PROCESSING IN 8-10 YEAR OLD CHILDREN: EVIDENCE THROUGH BEHAVIORAL AND ERP MEASURE", Journal of the All India Institute of Speech & Hearing, 2012.
Publication
<1%

21 linguisticsnewsfeeds.com
Internet Source
<1%

22 Christine Weber-Fox. "Atypical neural functions underlying phonological processing and silent rehearsal in children who stutter", Developmental Science, 3/2008
Publication
<1%

23 Submitted to National Taiwan Normal University
Student Paper
<1%

24 Weber-Fox, Christine. "Stuttering and natural speech processing of semantic and syntactic constraints on verbs.(Report)", Journal of
<1%

Speech, Language, and Hearing, Oct 2008 Issue
Publication

---

25 Juan Segui. "Priming word recognition with orthographic neighbors: Effects of relative prime-target frequency.", Journal of Experimental Psychology Human Perception & Performance, 1990 — <1%
Publication

---

26 www.britannica.com — <1%
Internet Source

---

27 www.psykosyntesforum.se — <1%
Internet Source

---

28 Cutting, Laurie E., Amy Clements-Stephens, Kenneth R. Pugh, Scott Burns, Aize Cao, James J. Pekar, Nicole Davis, and Sheryl Rimrodt. "Not All Reading Disabilities are Dyslexia: Distinct Neurobiology of Specific Comprehension Deficits", Brain Connectivity, 2012. — <1%
Publication

---

29 Ratner, N.B.. "Linguistic analysis of a bilingual stutterer", Journal of Fluency Disorders, 198509 — <1%
Publication

---

30 Murase, Shinobu, Takashi Kawashima, Hirotaka Satake, and Seiichi Era. "An event-related potential investigation of sentence — <1%

processing in adults who stutter",
Neuroscience Research, 2016.
Publication

EXCLUDE QUOTES ON
EXCLUDE BIBLIOGRAPHY ON
EXCLUDE MATCHES < 7 WORDS