Original Article

Artigo Original

Lexical priming in fluent and with developmental stuttering children

Priming lexical em crianças fluentes e com gagueira do desenvolvimento

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Keywords

Stuttering
Child
Priming
Reaction time
Language
Speech
Methods

ABSTRACT

Purpose: To examine the possible relationship between lexical variables (categorization and naming) and developmental stuttering. **Methods**: Thirty Brazilian Portuguese speaking children with ages ranging from 7 to 9 years and 11 months participated in the study. We applied a lexical priming paradigm to experimentally investigate whether children with developmental stuttering (Research Group) differed from their fluent peers (Control Group), with respect to reaction time in three conditions — control (without prime); semantically related prime, and semantically independent prime — of two experimental tasks: categorization and naming of the target stimulus. **Results**: No difference between groups was observed in reaction time on the categorization task. However, there was a condition effect showing that, for both groups, reaction time was shorter in the semantically related prime condition when compared to the no prime condition. In the naming task, a between group difference was observed in reaction time, indicating a longer reaction time in the Research Group than the Control Group. There was no condition effect on naming, i.e. the Research Group showed slower reaction time regardless of prime type. **Conclusions**: The results confirm the hypothesis that, in children with developmental stuttering, readiness in motor programming of speech is slowed when compared to fluent children. There is no difference between groups when the lexical function does not require speech readiness.

Descritores

Gagueira
Criança
Priming
Tempo de reação
Linguagem
Fala
Métodos

RESUMO

Objetivo: Examinar a possível relação entre variáveis lexicais (categorização e nomeação) e gagueira do desenvolvimento. **Métodos**: Participaram do estudo 30 crianças falantes do português brasileiro, entre 7 a 9 anos e 11 meses. Foi utilizado o paradigma de *priming* lexical para investigar experimentalmente se as crianças com gagueira do desenvolvimento (Grupo Pesquisa) se diferenciam de seus pares fluentes (Grupo Controle), em relação ao tempo de reação em três condições de pesquisa — condição controle (sem *prime*); condição de *prime* semanticamente relacionado e condição de *prime* semanticamente independente —, em duas tarefas experimentais: categorização e nomeação do estímulo-alvo. **Resultados**: Na tarefa de categorização, não houve diferença no tempo de reação entre os grupos. O tempo de reação foi diferente para cada condição, porém, a variação foi similar em ambos os grupos. Houve efeito de *prime* entre as condições sem *prime* e *prime* relacionado indicando que, para ambos os grupos, o tempo de reação foi menor na condição de *prime* relacionado. Na tarefa de nomeação, houve diferença no tempo de reação entre os grupos. O tempo de reação no Grupo Pesquisa foi maior em relação ao Grupo Controle. Não houve efeito de *prime*, ou seja, em qualquer condição, o Grupo Pesquisa apresentou tempo de reação maior. **Conclus**ões: Os resultados da pesquisa confirmaram a hipótese de que, nas crianças com gagueira do desenvolvimento, a prontidão na programação motora da fala – *input* – é lentificada, em relação ao Grupo de Controle de crianças fluentes. Não há diferença entre os grupos quando a função lexical não exige prontidão para a fala.

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INTRODUCTION

According to the paradigm of speech motor processing, the speech motor programming generates the production of quick and smooth sequential movements. The action units (organized set of specific and ready for activation commands) are retrieved from memory and used for each specific motor situation. Although not all movements are not produced in exactly the same manner, their essential characteristics are maintained because the motor programs are widespread and capture invariant movement aspects. The Generalized Motor Program (GMP) consists on a movement pattern that specifies which muscles are used, the duration of the action and the relative strength of muscle contractions[1,2].

The association between GMPs (speech) and developmental factors (genetic and environmental) synergistically integrates with other systems responsible for speech production (e.g. respiratory, linguistic, psychological, etc.). The GMPs of speech correspond to the motor commands associated with phoneme, syllable, word, or even to the automatic sequences of speech (words frequently produced in the same sequence — called automatic speech — such as: *good morning; how are you?;* counting numbers; speaking the days of the week, etc.)[1,2].

Based on the goal of the movement (audibly speaking a word so that the listener can hear it) and the available conditions (ambient noise level, distance from the listener, the initial position of the mandible), the GMP associated with the target sound is complemented with the parameters provided in motor scheme (expiratory muscle force for regulating the loudness of emission). The sensory consequences evaluate the result of production and accept this production or modify the motor program in a new tentative[1,2].

The approach of developmental stuttering - explained within the discussed motor model - seeks to justify the occurrence of unintended disruption of the flow of speech, without the possibility of spontaneous recovery, as a deficit in motor programming of speech impaired in the generation of the GMP. The deficit in motor programming of speech — by the impairment in the generation of the GMP — may result from organizational and temporal movement failures; from failures in the effectiveness and adaptability of the motor schema and/or the feedback effects (auditory and somatosensory)[1,2].

The hypothesis that developmental stuttering is due to deficits in motor programming of speech (by compromising the generation GMP) explain the difference in performance found in the speech of individuals who stutter in auto-expressive situations (subject to disruptions, as it is spontaneously generated, requiring capacity to adapt to sudden and frequent changes of motor patterns) and in automatic speech situations (almost always fluent as it is generated within GMPs ready and available)[1-3].

Within the motor speech programming model presented above, there is an intrinsic link between the speech motor processing and the language processing (linguistic and motor units simultaneously operating in the preparation of command signals for speech production). During the acquisition and development of speech and language, the motor/linguistic operation is subject to constant adjustments to the formation of efficient interactive maps (constant and determined). This intrinsic link between motor processing of speech and language processing has been researched in developmental stuttering, especially in the pediatric population[4-8].

Among the possible avenues of research of intrinsic link between motor processing of speech and language processing, online analysis has constituted a segment of excellence for research of this nature given its power to capture data in a dynamic that is closer to the usual speech[9].

The experimental priming paradigm was selected for this study given its focus on empirical testing of hypotheses related to linguistic planning and processing. Priming refers to change or improvement in the performance of the participant while performing a cognitive function (e.g., lexical naming or categorization task) as a result of exposure to a stimulus or a previous experience[10].

Lexical priming involves the concept that a target stimulus (e.g. a figure) is processed and responded more quickly or precisely when preceded by a semantically related prime (e.g. a word with compatible semantic category with the target stimulus) than when compared to a prime not semantically related (e.g., a word with semantic category non-compatible with the target stimulus). The prime stimulus presentation influences the reaction time of the participant. The reaction time will be shorter or longer depending on the type of prime used. If the prime and target stimulus are semantically related (e.g. auditory prime = cat; target figure = dog), lexical encoding will be faster, so the reaction time — both to classify as to name the stimulus - will be lower (compared with the control condition without priming). Conversely, if the prime and target stimuli are semantically unrelated (e.g. auditory prime = fork; target figure = dog), lexical encoding will be slower — such to classify as to name the stimulus — and the time reaction will be higher (compared with the control condition without prime)[10].

The reaction time measure (usually conducted on scales of milliseconds) enables the researcher to analyze the approximate time of lexical access or encoding of other cognitive processes of the participant and, therefore, the processing speed analysis at different linguistic domains. The measurement of reaction time is obtained by means of accurate and specific computer programs such as the E-Prime Experimental Control Software (PST, Inc.).

Offline lexical studies (by the application of structured protocols for evaluating the lexical performance) in children with developmental stuttering are not consensual. Some studies indicate that children who stutter have lexical coding and organization skills less developed than their fluent peers[9,11-15]. Other studies have found no differences between the groups[16,17]. These discrepancies can be attributed to methodological differences such as different inclusion criteria (such as stuttering diagnosis and age) as well as different tasks and materials used.

Studies of reaction time in lexical priming tasks can contribute to the expansion of knowledge about the influence of

linguistic variables in stuttering children[18]. The purpose of the present study is to use a priming paradigm to experimentally access the behavior of children who stutter in tasks of lexical categorization and naming. The variable reaction time was analyzed by comparing the results obtained with fluent children and children with developmental stuttering. Three testing conditions were applied: control condition (no prime); semantically related prime condition and semantically independent prime condition on two different tasks (categorization and naming the target stimulus).

METHODS

Ethical procedures

The research project was approved by the Ethics Committee of the Faculty of Medicine, Universidade de São Paulo (USP), under protocol number 069/10. All parents or guardians signed a consent form. The research did not involve invasive or unproven experimental technique, characterizing the study as low risk.

Participants

The study included 30 Brazilian Portuguese speaking children between 7 and 9 years and 11 months of both genders (22 boys and 8 girls, considered the proportional incidence rate of stuttering 3.5 ♂ / ♀ 1) and socioeconomic and cultural background according to the IBGE meta-data of C/D classes. The children were divided into two groups:

- Research Group (RG) − composed of 15 children diagnosed with developmental stuttering for at least 24 months;
- Control Group (CG) – composed of 15 children with typical language development, matched by gender and age (± three months) to participants from the GP.

The children included in the GP were recruited at the Laboratory of Speech Fluency, Facial Functions and Dysphagia, Department of Physical Therapy, Speech-Language Pathology and Audiology, Faculty of Medicine, Universidade de São Paulo. Children from the GC were recruited at public schools in the metropolitan region of São Paulo.

Inclusion Criteria

- Inclusion criteria for both groups: absence of severe comorbidities; absence of oral motor disorder; absence of social and emotional difficulties; performance within normal limits in Part B (Vocabulary) of the ABFW Child Language Test [19]; hearing thresholds within normal limits.
- RG inclusion criteria: stuttering severity of at least 2% SLD - stuttering like disfluencies per 100 syllables[20].
- CG inclusion criteria: no complaint or history of any language disorder; performance within normal limits in Part B (Vocabulary) of the ABFW Child Language Test[19];

Materials

The experiment was developed and presented on the E-Prime Experimental Control Software (PST, Inc.). The sequence and order of presentation of the target figures and the auditory prime as well as the collection and analysis of reaction time were performed, randomized and controlled by the E-Prime Experimental Control Software (PST, Inc.). The auditory primes were presented through computer speakers (DELL SRS Premium Sound) with the volume control at the same intensity for all subjects in both groups. For the categorization task, the responses were captured by the response box (PST, Inc.). The recording of naming responses was made through a unidirectional microphone (model MB-3K, Audio-Technica®). The priming data was analyzed on the E-Merge software (PST, Inc.). Data sheets were assembled in Microsoft Office Excel 2007. Statistical analysis was performed using the Statistica 8 software (StatSoft, Inc.).

Procedures

Lexical priming conditions

A lexical naming and classification experiment was designed by the authors on E-Prime Experimental Control Software (PST, Inc.) to collect reaction time information during the three conditions (control condition − no prime; semantically related prime condition; and semantically independent prime condition). The three conditions for categorization of figures were used in counterbalanced order to all participants in accordance with method previously applied[18]:

- no prime, in which no auditory stimulus was presented before the figure display;
- semantically related prime, in which a word semantically related to the target figure was auditorially presented 700 ms before the presentation of the figure on the computer screen;
- semantically independent prime, in which a word not semantically related was auditorially presented 700 ms before the presentation of the figure on the computer screen.

An interval of 700 ms was applied after the onset of the presentation of the auditory stimulus to ensure that no auditory prime was superimposed to the visual onset of the target figure.

Categorization and naming of target stimuli

For the naming task, each participant was presented with a set of figures 27 in each of the three different conditions (no prime, related prime, and independent prime). For the categorization task, each participant was presented with another set of figures 27 (different from those in the naming task) in each of the three different conditions (no prime, related prime, and independent prime).

The 54 figures were selected from the set of 118 figures of Part B of ABFW Child Language Test[19] by simple random sampling (random number table). To control for possible effects of experience related to the figure, the ABFW test was applied only after the data collection of the experiment. And,

to avoid possible effects of experience related prime condition, figure presentation order within a condition was randomized by E-Prime.

The auditory primes were recorded by a native speaker of Brazilian Portuguese. Auditory stimuli were digitized and normalized on the Praat software.

General Procedure and reaction time measures

All participants performed the tasks seated in a comfortable chair (with specific adjustment in height) in front of a computer at an average distance of 30 cm from the screen.

Table 1. Mean (standard deviation) of age, vocabulary score and % of stuttering like disfluencies (fluency) for the Research group and Control group

Variables	RG Mean (SD)	CG Mean (SD)
Age	9.3 (1.4)	9.6 (1.3)
Vocabulary	85.1 (5.1)	86.5 (3.2)
% SLD (fluency)	7.8 (5.9)	1.1 (1.7)

Legends: RG = research group; CG = control group; SD = standard deviation; SLD = stuttering like disfluencies

The instruction provided for the naming no task of the experiment was: "Figures will appear on the computer screen. Say the name of the figure that appears on the screen as fast as you can and as soon as it appears". The E-Prime software controlled the presentation of the target figure and the auditory prime, as well as naming latency (speech reaction time in milliseconds) measured from the onset of the presentation of the target figure to the early onset of speech.

The instruction provided for categorization task of the experiment was: "Figures will appear on the computer screen. Press 1 if the figure that appears on the computer is a food and 2 if it is not a food. The E-Prime software controlled the presentation of the target figure and the auditory prime, as well as the categorization latency (reaction time in milliseconds) measured from the onset of the presentation of the target figure to the selection of the participant's response.

RESULTS

Only correct responses were included in the analysis of reaction time. The three largest and the three shorter reaction times for each participant in each prime condition were excluded. In the naming task, only fluent productions of the RG were considered in order to eliminate the interference of speech ruptures on reaction time. Only one production of one of the participants had to be excluded due to the presence of blocking on speech production.

The inferential statistical analysis was performed using one-way and repeated measures analysis of variance (ANOVA) to investigate differences in reaction time of the tasks of categorizing and naming between stuttering and non-stuttering children in the three priming conditions. The significance of 5% was adopted.

When performing repeated measures ANOVA, one should ensure that the data assume a sphericity criterion, which assumes that the variances of the differences between the data of a participant in different conditions are equal. Mauchly's test is used to evaluate this criterion. If Mauchly's test is significant ($p<0.05$), we must conclude that there are significant differences between the variances of the differences and therefore the criterion of sphericity is not assumed. In this case, we fix the degrees of freedom for this ANOVA so that F values provided are reliable. In the present study, as Mauchly's test was significant we applied the Greenhouse-Geisser correction to the degrees of freedom of the repeated measures ANOVA.

Categorization task

Figure 1 shows the mean reaction time (in milliseconds) and confidence interval (0.95) for the three prime conditions (no prime, independent prime and related prime) for both groups in the categorization task.

Mauchly's test indicated that the data assume the criterion of sphericity (Mauchly's W=0.996, p=0.431). Therefore, the repeated measures ANOVA was performed without the correction of degrees of freedom.

No significant interaction between prime and group (F (2,944)=2.171, p=0.115) was found, indicating that there is no variation in reaction time between the groups in the different prime conditions. A priori comparisons with one-way ANOVAs revealed no differences between the groups

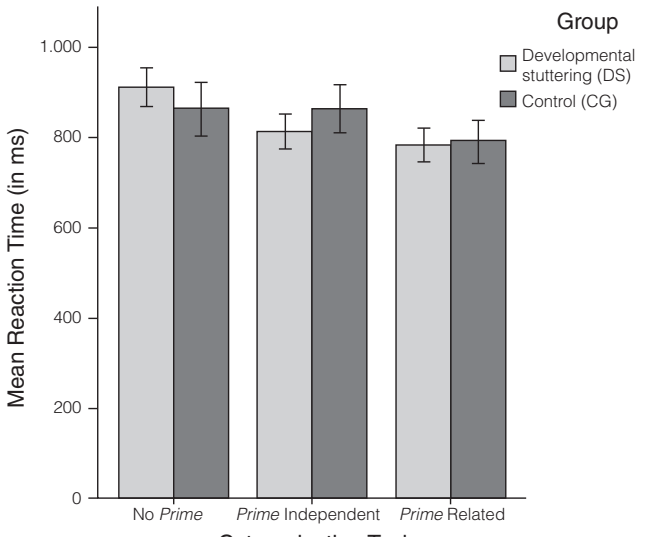

Figure 1. Mean reaction time (in ms) for the categorization task obtained for the control and research groups on the three different prime conditions (no prime, independent prime, and related prime)

according to the type of prime (no prime: F (1,551)=2.612, p=0.107; independent prime: F (1,558)=1.959, p=0.162; related prime: F (1,560)=0.665, p=0.415).

In both groups, the results revealed a significant effect of prime condition (F (2,944)=9.08, p<0.001), indicating that the reaction time varied according to the type of prime displayed. *Post hoc* analyzes indicated significant difference

between the no prime condition and the related prime condition (p<0.001).

Naming task

Figure 2 shows the average reaction time (in milliseconds) for the three prime conditions (no prime, independent prime and related prime) for both groups in the naming task.

Mauchly's test indicated that the data does not assume the criterion of sphericity (Mauchly's W=0.962, p<0.001). Therefore, the degrees of freedom of the repeated measures ANOVA were corrected using the Greenhouse-Geisser estimators.

The repeated measures ANOVA revealed no significant interaction between prime and group (F (1.926, 941.974) =0.158, p=0.846). However, a priori comparisons made by means of one-way ANOVAs revealed differences between the groups

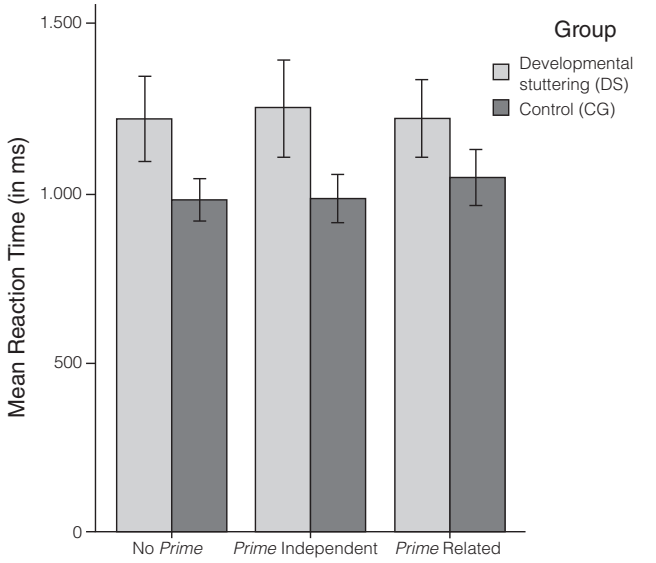

Figure 2. Mean reaction time (in ms) for the naming task obtained for the control and research groups on the three different prime conditions (no prime, independent prime, and related prime)

for each type of prime (no prime: F (1,571)=6.104, p=0.014; independent prime: F (1,569)=5.914, p=0.015; related prime: F (1,560)=4.621, p=0.032).

Results showed no significant effect of prime condition (F (1.926, 941.974)=0.080, p=0.917), indicating that the reaction time did not vary according to the type of prime for any of the groups.

DISCUSSION

The present study examined the possible relationship between lexical variables (categorization and naming) and developmental stuttering. It consists on an original study because, to our knowledge, no studies investigating the variable naming this population are found[18]. A lexical priming paradigm was used to experimentally investigate whether children with developmental stuttering differ from their fluent peers in relation to reaction time in three research conditions (control condition (no prime); semantically related prime condition; and semantically independent prime condition) on tasks of categorizing and naming the target stimulus.

The results indicate that, in the categorization task there is no difference in reaction time between groups. The reaction time is different for each condition, but the variation is similar for both groups. There is a prime effect between the no prime and related prime conditions, indicating that for both groups the reaction time is shorter in the semantically related prime condition.

The results reveal a difference in reaction time between groups on the naming task. The reaction time in the research group is greater than the control group. There is however, no priming effect, indicating that in any condition the research group presents greater reaction time.

Reaction time effect

Categorization task

The results of this study indicated no difference in reaction time between groups in the categorization task (activity that did not involve speech).

There is no consensus in the literature on the relationship between stuttering and lexical access. Some authors[21,22] suggest that stuttering may reflect a disturbance in lexical access. In contrast, other studies suggest that stuttering is not related to the difficulty of lexical retrieval[23,24], corroborating the results of the present study.

Naming task

The results of this study indicated that the reaction time was higher for the group with stuttering in this task (i.e., there seems to be a lexical effect on stuttering only when motor activity of speech is recruited). This result corroborates previous studies conducted with English-speaking children[9,14,15] subjected to the same testing conditions[12,13,18].

The increased reaction time for speech in individuals with stuttering seems to be indicative of the impact of a failure in the temporalization of the processing involved in speech[7,8,19,22,25-27]. The individuals who stutter do not seem to have the same system readiness for motor speech activity[25]. This deficit in the readiness for speech may result in failure of this temporalization between processes, and this is reflected in higher latencies for the onset of verbal activity, even when considering only fluent speech of individuals who stutter[25].

One of the most current theories about stuttering, the EXPLAN model (derived from EX − motor execution and PLAN, the parallel mechanism linguistic planning), considers the interaction between language and motor systems[26,27]. The authors of that model consider that linguistic planning and motor execution are processes that occur in parallel, but independently. Because of the independence between the

processes (planning and execution), they can be scaled and simultaneous, thus allowing that a segment can be planned while another is already being executed. This concept can be applied both to segments of the sentences (words) as to the segments of words (syllables). Thus, the authors suggest that there is no error in the planning of the segment. In contrast, what can occur is that the segment is not yet completely ready for execution, thereby occurring a failure of the processing temporalization.

Priming effect

An effect of prime was found in the task of categorization; faster reaction time for related prime than for no prime and unrelated prime conditions was found for both groups. This result supports the lexical priming theory in stuttering, which considers that a target stimulus is processed and responded more quickly or precisely when preceded by a prime semantically related than a not semantically related prime[28-30].

In the naming task, no effect of prime was found, contrasting with the findings of a previous study[18] in which a priming effect was reported for naming for both the group of stuttering children and for the group of fluent children. Although both studies used similar methodology, two variables may have contributed to this discrepancy. First, the age range of the participants was different (in the American study children were between 3 years and 5 years and 11 months and, in the current study, children were between 7 years and 9 years and 11 months). Second, the current study controlled the variable diagnosis of developmental stuttering with chronic symptoms for at least 24 months.

CONCLUSION

The hypothesis that readiness in speech motor programming is slowed in children with developmental stuttering when compared to the control group of fluent children is confirmed. However, there is no difference between the groups when the lexical function does not require speech readiness.

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** CRFA was responsible for the project and study design, as well as the general counseling of the stages of execution and elaboration of the manuscript; FSJ followed-up the collection and colaborated with data analysis; TMFT was in charge of data collection and formatting.*

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