Memória operacional fonológica e suas relações com o desenvolvimento da linguagem infantil***

Phonological working memory and its relationship with language development in children

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Abstract

Background: phonological working memory and typical language development in children. Aim: to describe and discuss findings of researches concerning the assessment of phonological working memory in normally developing children undertaken since the 1980's. Aim: to present a systematic literature review regarding the phonological working memory and its relationship with normal language development. Method: A systematic review of the literature on phonological working memory and its relationship with language development skills of normal children was made. The used material involved books, monographs, thesis, dissertations and articles stored in Lilacs, Pubmed, Scielo and Medline databases. An analysis was made considering the applied tests and the results regarding the effects of extension and age and the relationship of these variables with phonological working memory for speakers of English and the Brazilian Portuguese language. Conclusion: according to the consulted literature, studies indicate a relationship between the phonological and lexical knowledge and the phonological working memory in children with normal language development.

Key Words: Working Memory; Normal Language Development; Child Language; Review Literature.

Resumo

Tema: memória operacional fonológica e desenvolvimento de linguagem em crianças com desenvolvimento normal de linguagem. Objetivo: descrever e discutir os achados encontrados sobre a avaliação da memória operacional fonológica em crianças em desenvolvimento normal desde a década de oitenta. Foi realizada uma revisão sistemática da literatura sobre memória operacional fonológica e sua relação com o desenvolvimento das habilidades de linguagem em crianças normais. As fontes utilizadas foram livros, monografias, teses, dissertações e artigos publicados nas bases de dados Lilacs, Pubmed, Scielo e Medline. Foram analisados nessas pesquisas a constituição dos testes e os resultados referentes aos efeitos de extensão e idade em relação à memória operacional fonológica para falantes do Inglês e do Português do Brasil. Conclusão: de acordo com a literatura consultada, esses estudos demonstraram uma relação entre o conhecimento fonológico e lexical e a memória operacional fonológica em crianças em desenvolvimento normal de linguagem.

Palavras-Chave: Memória de Trabalho; Desenvolvimento Normal de Linguagem; Linguagem Infantil; Literatura de Revisão.

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Introduction

Literature review is part of the theoretical introduction presented on doctoral dissertation named phonological working memory and phrases comprehension in typical language development children aged between 3:0 and 6:11 years old1. The aim of this review is to describe the model proposed previously to the functioning of the phonological working memory and its updates from experimental researches in the last 20 years. Moreover, it is also presented a brief review from national and international literature about phonological memory and the correlation between phonological working memory (PWM) and children with typical language development.

The review was made from books, monographs, thesis, dissertations and articles mostly stored on Lilacs, Pubmed, Scielo and MEDLINE databases. Studies were selected according to its relation to the models, evaluation methods and test results from evaluation of PWM. Researches showing the correlation between language and PWM in typically developing children were also used. No time period was established to the bibliographical survey.

Phonological working memory models

Working memory is the one responsible for the storage and manipulation of information needed for cognitive operations2. This name is usually presented as a synonym to short duration memory, short term memory or working memory, but after results from some experimental researches this term appeared to be inadequate since it represented a very simple system to deal with different types of information in short time periods. The authors from this study are going to use the term Phonological Working Memory (PWM) referring specifically to the phonological system.

The PWM is a limited capacity system because there is a limited space to the temporary storage of verbal material while information is processed. This memory has an attention controller (an executive central system) assisted by two other support systems (a viso-space and a phonological system) that are responsible for the storage and for the temporary manipulation of information3.

Executive central system is the responsible for regulation of information on PWM, for management of the processing and information storage and for connection between viso-space and phonological systems. This memory is also correlated to other cognitive components like the selection of recover strategies, selective attention, inhibition, logical thought, mental mathematics, and the connection to long term memory4.

Phonological circuit comprehends phonological information storage (phonological buffer) and articulatory control system (subvocal process or rehearsal). Phonological storage represents a temporary deposit from verbal items of the phonological codes that occur in one or two seconds. This storage corresponds to a mnemonic window where input sequences are maintained in serial order while its items are processed and stored. Articulatory control system is responsible to keep phonological material stored on PWM until they are phonologically codified by using a sub vocal assay process that allows phonological codes to be refreshed by a cyclic repetition process5,6. These phonological codes are stored on PWM and sequentially converted into articulatory voiced motor programs (mentally or verbally) one after the other7.

The implications between language and PWM may be etiologically related to the sub vocal assay process and to the planning of speech (phonological output)8. The ability to make and to retain a precise phonological speech sequence is also inside this system. This ability assures the listener to process verbal input especially when the order of the sequence is important for its comprehension9.

Recent studies aiming to explain executive central system functioning are presenting a fourth component to the PWM10,11 model so called episodic retainer that corresponds to a limited capacity system which allows the evoked information from long term memory to become conscientious. The episodic retainer is an attentional system that supervises stimuli supposed to be processed by directing its attention, regulating and selecting the information flow inside PWM system so that the requested task is fulfilled in appropriate time12.

There are some factors that can affect the PWM in relation to its phonological storage: the similarity phonological effect and the word length effect3. Researches involving similarity phonological effect demonstrate that sequences of phonologically similar words are less remembered than non-similar words sequences13,14 suggesting that verbal information is represented through an specific phonological storage instead of using any other storage system like visual or semantic ones15. This way phonological codes decrease faster when they are similar or at the same speed of non-similar codes,

however, its reconstruction or reintegration is more difficult16.

In relation to the length effect some authors17,18 observed a better performance in the repetition of sequences of words which had slower time of articulation to pronounce phonemes, syllables, words and pseudo-words. This effect occurs because items that are faster pronounced are less probable to decrease from PWM before its repetition is completely finished what makes the reverberation process easier to occur.

Considering preschool children, PWM can be evaluated by using tests with digits repetition (digit span), words repetition (word span) and non-words repetition tasks (non word span)5,19,20. Scholar children can be evaluated using the same tasks presented previously plus other ones that are able to evaluate the capacity of PWM by using tests that require both storage and information processing21-23.

Phonological working memory and language development

PWM development has a determinant place on verbal language development and infantile communication since it permits the child to remember and to repeat past events in the absence of stimuli. Besides it permits the child to formally and informally learn, to acquire new knowledge and to integrate different types of information. Language and memory develop according to the age growth; they interact and depends one on the other. PWM is transitory and more connected to syntactic and phonological components of language.

During language acquisition the PWM permits to the learning child to analyze structural properties of the language. As language development grows PWM has a critical place on the linguistic processing3.

PMW is related to syntax because it maintains the main lexical items to phrase construction until the moment that syntactic rules and articulatory programming can be applied to speech production. Deficits on PWM that compromise temporary maintenance of linguistic information can be identified by the use of syntactically less complex phrases24.

Linguistic knowledge and PWM work together and because they interact deficits on PWM may produce difficulties on comprehension and language learning since the child will not be able to recall the linguistic information or to process it fast enough. There is also some children presenting deficit on linguistic knowledge what can be observed by difficulties on phrase comprehension or on the ability of learning new words. Due to the insufficient linguistic knowledge children with such deficit are not able to correctly process information what demonstrates the bi-directional influence of language on PWM25.

Processing speech abilities can also be evaluated by non-words repetition task which includes auditory memory and discrimination, construction of auditory representations and/or motor speech planning. The failure on these abilities may also justify a low performance on tasks of non-words repetition26.

An adequate performance on non-words repetition task depends on phonological abilities of the child and on a preserved temporary phonological information storage system27. Articulatory abilities measured by the velocity of words and non-words repetition associated to a test that diminished articulatory demand suggest that oral motor and articulatory abilities are not related to the performance on PWM22,28.

Some studies done to verify non-words repetition abilities by typically developing English speaking children aged 4:0 years-old demonstrated a higher number of correct repetitions according to age growth. Besides, authors showed a correlation between language development and PWM since children who presented a higher number of correct answers at repetition task were the ones presenting a higher number of syntactically complex words and sentences on their repertoire8.

Adaptation and validation of Children´s Test of Nonword Repetition (CNRep) was done for 182 Brazilian children with typical language development aged between 4:0 and 10:0 years old. Authors from the study verified age, length, scholarship and lexicality effects. Length effect was observed by decrease on the repetition of two up to five syllables for all ages. Scholarship effect was noticed in just one child over 5:0 years-old. This effect can be explained by the influence of reading and writing learning process and the acquisition of orthographic principles that are able to modulate processing and sub-lexical phonological awareness. Lexicality effect can be explained by the number of correct repetitions which were more associated to lexical knowledge than to pseudo-words length29.

Other studies have demonstrated a positive correlation between PWM tests performance and linguistic development in relation to new words learning process. This correlation exists because listener must retain the phonological form on his/

her PWM of a new lexical item and associate it with its semantic and synthetic correspondents30.

Receptive vocabulary is more correlated to the ability of non-words repetition than to digits repetition even though evidences point to a common origin for both activities inside PWM. This difference is supposed to occur because non-words repetition needs the perception, codification, storage, recover and production of a new phonological information to be realized and just after that whole information can be transferred to the long term memory27.

Conclusion

Studies findings presented on this review demonstrated that for both English and Brazilian Portuguese speakers there was a better performance on PWM tests depending on age growth. PMW tests based on words and non-words or pseudo-words repetition verified a length effect according to the decrease of the number of syllables for all ages. This fact confirms a limited capacity of a temporary storage for PWM and an increase of phonological information retention depending on development. The increase at the storage and processing capacity from PWM facilitates the acquisition of new words and comprehension of more complex sentences containing redundant linguistic information. Moreover PWM permits the child to acquire metalinguistic abilities like grammatical judgment of sentences and phonological awareness tasks.

Many studies proved the existence of a correlation between linguistic knowledge (especially lexical and phonological) and PWM in typically language developing Brazilian Portuguese and English speaking children.

Considering these affirmations the largest the vocabulary of a child is, the bigger is his/her sub-lexical and morphological knowledge what will facilitate child performance in words and pseudo-words repetition activities.

Phonological memory is also correlated to the child phonological development as well as to the acquisition and fast access to phonological and articulatory properties. Thus, the better articulation skills of the child are, the greater will be the facility to produce a target non-word before it exceeds the time that the item to be repeated can be stored in short memory.

Results of studies with typically and not typically speak and language development children demonstrate that the capacity from PWM depends on the conversion of the acoustic signal into phonological, on the identification of a sound for further phonological representation into a correct sequence and on proper storage of information on phonological buffer. For the phonological information to be kept activated it must be refreshed from reverberation process or sub vocal assay until precisely articulatory production occurs. This way deficits on development of any of the presented abilities may lead to phonological working memory difficulties.

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