



**Alberto Filgueiras**

**Neural basis of phonological working memory: testing  
theoretical models using fMRI meta-analysis**

**TESE DE DOUTORADO**

Thesis presented to the Departamento de Psicologia, PUC-Rio, as partial fulfillment of the requirements for the degree of Doutor em Psicologia in the Departamento de Psicologia do Centro de Teologia e Ciências Humanas da PUC-Rio.

Advisor: Prof. Jesus Landeira-Fernandez  
Co-advisor: Prof. Lisa Archibald

Rio de Janeiro  
February 2015



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## Abstract

Filgueiras, Alberto; Landeira-Fernandez, Jesus (Advisor). **Neural basis of phonological working memory: testing theoretical models using fMRI meta-analysis**. Rio de Janeiro, 2015. 99p. Ph.D. Thesis - Departamento de Psicologia, Pontifícia Universidade Católica do Rio de Janeiro

Phonological working memory can be defined as a set of mental processes that encode, store, maintain, manipulate, and retrieve auditory information. It is the foundation for other complex and higher cognitive functions, such as planning, task switching, logical and abstract reasoning, and language. Some evidence shows a relationship between the development of phonological working memory and further language acquisition and general fluid intelligence. Current neuroscience discusses the networks and brain regions that account for working memory. Working memory relies on a parietal-frontal network that is divided according to memory and attention. It has been hypothesized that the prefrontal cortex plays an important role in working memory tasks. Working memory is a relatively recent psychological discovery, and several authors suggest different theoretical models to explain it. Among the most important are those proposed by Alan Baddeley, Nelson Cowan, and Adele Diamond, which have been the most studied and implemented in attempts to test their hypotheses. Studying the neural basis of phonological working memory will help shed light on the organization and location of mnemonic and attentional functions in the brain. The present study comprised a meta-analysis of functional magnetic resonance imaging studies on phonological working memory that were published between 2000 and 2014. The results showed that one region in the temporal lobe and another region in the fronto-polar cortex were clustered intersections of phonological working memory, suggesting that these brain regions may account for sensorial memory and the central executive, respectively.

## Keywords

Neuroscience; Working Memory; Functional Magnetic Resonance Imaging; Meta-analysis.

## Resumo

Filgueiras, Alberto; Landeira-Fernandez, Jesus (Orientador). **Bases neurais da memória de trabalho fonológica: testando modelos teóricos usando meta-análise de RMf.** Rio de Janeiro, 2015. 99p. Tese de Doutorado - Departamento de Psicologia, Pontifícia Universidade Católica do Rio de Janeiro.

A memória de trabalho fonológica pode ser definida como um grupo de processos mentais usados para codificar, guardar, manter, manipular e recuperar informações auditivas. É o alicerce de outras funções cognitivas superiores e mais complexas como o planejamento, mudança do foco da tarefa, raciocínio lógico e abstrato e linguagem. Algumas evidências mostram a relação entre o desenvolvimento da memória de trabalho fonológica e mais tarde a aquisição da linguagem e inteligência global fluida. A antropologia contemporânea discute o papel da memória de trabalho como uma forma rudimentar de pensamento e suas consequências para o desenvolvimento de ferramentas e cultura entre os homínídeos. Têm sido aceito que a expansão da região frontal do crânio abre espaço para novas formações corticais no cérebro, especialmente no lobo frontal. Crê-se que o córtex pré-frontal tem um importante papel em tarefas de memória de trabalho. Ao mesmo tempo, a memória de trabalho é uma descoberta psicológica recente e diversos autores sugerem diferentes modelos teóricos para explicá-la. Dentre os mais importantes, Alan Baddeley, Nelson Cowan e Adele Diamond são aqueles cujas teorias são as mais estudadas e implementadas pelos pesquisadores que testam suas teorias. Estudar a base neural da memória de trabalho fonológica pode ajudar a lançar luz sobre ambos os pontos: o papel do córtex pré-frontal na evolução humana especialmente no funcionamento da memória de trabalho, e qual modelo teórico é o mais confiável dentro de uma perspectiva neuropsicológica. Para fazer isso, conduzimos uma meta-análise usando o método de estimação de verossimilhança das ativações e discutimos os resultados alicerçados na psicologia evolutiva e cognitiva modernas.

## Palavras-chave

Neurociência; Memória de Trabalho; Ressonância Magnética funcional; Meta-análise.

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## List of Abbreviations

WM	Working Memory
LTM	Long-term Memory
STM	Short-term Memory
SM	Sensorial Memory
CE	Central Executive
FA	Focus of Attention
fMRI	Functional Magnetic Resonance Imaging
EEG	Electroencephalography
MEG	Magnetoencephalography
PET	Positron Emission Tomography
PFC	Prefrontal Cortex
FPC	Frontopolar Cortex
CC	Cingulate Cortex
PL	Parietal Lobe
TL	Temporal Lobe
FL	Frontal Lobe
SAS	Supervisory Attentional System
ALE	Activation Likelihood Estimation

“I do not think that measurement is an activity that is celebrated in our school system, and measurement is the life and blood of all sciences. In fact, those sciences that have not yet achieved a system of measurement cannot claim themselves to be matured subjects. So, take a look at everything Freud wrote, you look at that and where are the measurements? There are not. So, this is why Psychology has lacked so far behind the other sciences. They have not developed methods of measurement. So you struggle, you struggle the way Physics struggled when it first began, but you come along. For Psychology, in a few more hundred years.”

(Neil DeGrasse Tyson, *On the verge*)