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Semantic priming effect after left hemisphere stroke

O efeito de priming semântico após AVC no hemisfério esquerdo

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Abstract

Semantic priming effect (SPE) refers to a facilitation in processing a target due to the semantic association between that and a preceding stimulus (prime). Recent neuroimaging researches supports the hypothesis that brain left hemisphere (LH) plays an important role on this phenomenon. The purpose of the present study was to compare the SPE between patients with LH brain lesions and their controls at two different stimulus onset asynchronies (SOA)s (300ms and 500ms). The sample was composed by 17 patients with LH lesion after stroke and 17 healthy controls matched on sex, age and educational level. They performed a lexical decision task on the semantic priming paradigm. Data showed no differences between groups. Clinical and control group didn`t present SPE at the 300ms SOA whilst both groups presented it at the 500ms SOA. Those findings cannot be understood as patient's impairments on SPE once control group performed similarly.

Keywords: Semantic priming; stroke; brain; stimulus onset asynchrony; aphasia.

Resumo

O efeito de priming semântico se refere à facilitação no processamento de um estímulo alvo causada pela associação semântica existente entre este e um estímulo anterior (prime). Pesquisas recentes de neuroimagem corroboram a hipótese de que o hemisfério esquerdo tem um importante papel neste fenômeno. O objetivo do presente estudo foi comparar o efeito de priming semântico entre pacientes com lesão no hemisfério esquerdo e seus controles através de dois diferentes intervalos entre os estímulos (300ms e 500ms). A amostra foi composta por 17 pacientes com lesão no hemisfério esquerdo causada por acidente vascular cerebral e 17 controles pareados por sexo, idade e escolaridade. Os participantes realizaram uma tarefa de decisão lexical no paradigma do priming semântico. Os dados não mostraram entre os grupos. Nem o grupo clínico nem o controle apresentaram efeito de priming semântico com 300ms de intervalo entre os estímulos enquanto os dois grupos apresentaram no intervalo de 500ms. Esses achados não podem ser interpretados como déficit dos pacientes visto que os controles obtiveram um desempenho semelhante.

Palavras-chave: *Priming semântico; acidente vascular cerebral; cérebro; intervalo entre os estímulos; afasia.*

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1. Introduction

Semantic priming effect (SPE) is an improvement in processing performance derived from the context. This improvement is caused by the semantic association between the target and a preceding stimulus (prime) (Meyer & Schvaneveldt, 1971). According to functional magnetic resonance imaging (fMRI) studies on semantic priming during lexical decision tasks in healthy adults left hemisphere (LH) plays an important role in this phenomenon (Sachs et al., 2008, Sass, Krach, Sachs, & Kircher, 2009) .

Another evidence of the neural basis of the SPE comes from preserved SPE found in studies evaluating patients after right hemisphere lesions (Müller, 2012; Müller & Salles, 2013). Finding that patients with right hemisphere lesions behave similar to healthy subjects (e.g., Gagnon, Goulet, & Joanette, 1994; Müller, 2012) lead once again to the hypothesis that the main substrate of the SPE would be the LH.

In an attempt to understand the consequences of a LH on the SPE some studies were developed applying the semantic priming paradigm in aphasic (and therefore LH lesions) patients (Baum, 1997; Milberg & Blumstein, 1981; Milberg, Blumstein, Giovanello, & Misiurski, 2003) allowing indirect access to the semantic system. Findings of the SPE in those patients were not consistent, probably because of methodological differences among studies (number and characteristics of the patients' lesions, task stimuli, stimulus onset asynchrony, and so on).

Especially in what concerns non-fluent aphasia, a previous review (Salles, Holderbaum, Parente, Mansur, & Ansaldo, 2012) showed that some studies were able to find SPE on expressive aphasics (e.g., Hagoort, 1997; MimuraGoodglass, Milberg, 1996; PratherZurif, Love, & Brownell , 1997) whilst others were not (e.g., Bushel, 1996; Del Toro, 2000). Even when controlling Stimulus Onset Asynchrony (SOA) (an important source of variance in the SPE), results continued not to converge.

Considering the divergence of results in aphasic patients and the lack of studies in patients with LH lesion without aphasia, the aim of the present study was to compare the SPE between patients who had suffered a stroke to the LH and their controls at two different SOAs (300ms and 500ms).

2. Method

2.1 Participants

Sample was composed by 17 patients who had suffered a stroke to the LH and 17 healthy controls. Patients were eight males and nine females with ages ranging between 33 and 73 years old. Controls were matched on sex, age and educational level. Table 1 presents general characteristics of both groups. The absence of differences on age and educational level of both groups were proven by *t* tests comparisons. General inclusion criteria for both groups, clinic and control, included a minimum of four years of regular education, right manual dominance, Brazilian Portuguese as native language and absence of depressions evidence.

	Patients (*n* = 17)	*Controls* (*n* = 17)		
			t	*p*
Age	57.9 (10.4) 33; 73	57.7 (10,5) 32; 75	.06	.95
Years of education	8.2 (4.1) 4; 16	8.5 (4.3) 4;17	-.25	.81
Male/ Female	8/ 9	8/ 9		

Note. Age and years of education are expressed in terms of Means (Standard Deviation) and amplitude. Independent sample t test were used to compare groups.

Table 1 General characteristics of clinical and control groups

Clinical group were selected from the two Brazilian public hospitals. The following inclusion criteria were adopted: have had LH unilateral stroke, confirmed by neuroimage exams; have had the stroke at least 2 months before assessment; do not had any other neurological disease and present preserved comprehension. According to their language abilities (evaluated by Token Test and Boston Diagnostic Aphasia Examination Test – short form), they were divided in two categories: expressive aphasic and non-aphasics (see Table 2 for more information).

Controls were selected by convenience in educational institutions, companies, and among acquaintances. Besides matching characteristics and general including criteria they were chosen in the absence of neurological and/or suspicion of demential process (when older than 60 years old), evaluated by Mini-Mental State Examination.

Patient	Age (years)	Years of Education	Socioeconomic Status	Stroke	Months Post onset	LH local lesion	Aphasia
MP1	63	10	C1	H	126	T	T. Motor
MP 2	70	7	B2	I	45	F	T. Motor
MP3	53	5	B2	I	125	FTP	Broca
MP4	66	8	C2	I	8	FT	Broca
MP5	49	11	C1	H	36	T	T. Motor
MP6	54	8	C1	H	2	BG	Not aphasic
MP7	52	16	A2	I	18	CR	Not aphasic
MP8	60	15	B2	I	36	IC	Not aphasic
FP1	33	15	C1	I	40	Unknown	T. Motor
FP2	46	9	C1	I	70	FT	Broca
FP3	48	15	C2	I	60	FTP	Broca
FP4	73	4	C2	I	24	PO	Not aphasic
FP5	70	4	C1	I	7	TH	Not aphasic
FP6	63	4	B2	I	69	TP	Broca
FP7	58	5	C1	H	29	BG	Not aphasic
FP8	66	4	C2	I	120	FTP	Broca
FP9	61	9	C1	I	45	TH	Not aphasic

Note. MP= male patient; FP= female patient; H= hemorragic stroke; I= isquemic stroke; T=temporal; F=frontal; P= parietal; O=occipitalBG= basal ganglia; CR=corona radiate; IC=internal capsule; TH=thalamus; T. Motor = transcortical motor

Table 2 Detailed information about LH patients (clinical group)

2.2 Design

The design of the present study was mixed, transversal and quasi-experimental of contrasting groups (Naschmias & Naschmias, 1996) of the case-control type, in which every patient of the clinical group had a neurological healthy control participant matched on age, sex and educational level.

2.3 Procedures

The present study followed the ethical principles of research in human beings in accordance with Helsinki Declaration. In general three sessions were needed to apply all the instruments. At first instruments to verify inclusion criteria were applied, followed by Brief Neuropsycholinguistic Evaluation Instrument for Expressive Aphasics NEUPSILIN-Af and Lexical Decision Task.

2.4 Instruments and specific procedures

a) Instrumento de Avaliação Neuropsicolinguística Breve para Afásicos Expressivos NEUPSILIN-Af (Brief Neuropsycholinguistic Evaluation Instrument for Expressive Aphasics) (Fontoura, Rodrigues, Parente, Fonseca, & Salles, 2011): It is an adaptation of the Instrumento de Avaliação Neuropsicológica Breve NEUPSILIN (Brief Neuropsychological Assessment Battery NEUPSILIN) (Fonseca, Salles, & Parente, 2009) to be used with patients with expressive aphasia. It exams cognitive function such as: temporal and spatial orientation, attention, perception, arithmetic abilities, language, memory, motor abilities and executive functions.

b) Lexical decision task in a semantic priming paradigm (adapted from Holderbaum, 2009 and Holderbaum & Salles, 2011): the 95 word targets had between two and seven letters, being mostly of them concrete and abstract nouns and some adjectives and adverbs. The prime selected to precede the target in the related condition was the most evoked by participants of a pilot study (Salles et al., 2008; Zortea & Salles, 2012). Idiosyncratic answers of the same study were used to create unrelated primes just like primes of the pseudowords. They were carefully selected to have a similar length when compared to the semantically related prime and no structural or semantic relation with the target. Table 3 exhibits example of stimuli used in each condition: word targets and their related and unrelated primes, pseudoword targets and their preceding primes.

Word targets	*Related primes*	*Unrelated primes*	*Primes preceding pseudowords*	*Pseudoword targets*
RÁDIO (radio)	música (music)	murcho (withered)	sangue (blood)	RÍDIA
FRALDA (diaper)	bebê (baby)	chave (key)	real (real)	FROLPA
SEDE (thirst)	água (water)	piso (floor)	gibi (comic)	SADU
FORTE (strong)	músculo (muscle)	irreal (unreal)	faísca (spark)	FARTI
BOLA (ball)	futebol (soccer)	legume (vegetable)	tijolo (brick)	POBA

Table 3 Example of stimuli used in each condition: Word targets and their related and unrelated primes, pseudoword targets and their preceding primes

The time line of the experiments went as follows: prime appeared in lowercase letters for 300ms. In the case of 300ms SOA, the target was presented right after prime. On the other hand, in the 500ms SOA experiment, a distracter (+) was presented for 200ms between prime and target. In both cases target rested on screen for up to 3000ms. The experiment was presented using an E-prime computer program, which also recorded the answers and latencies. Stimuli were seen in the center of the screen, in black letters (font Arial 24) on a white background. Primes appeared in lowercase letters while targets were shown in uppercase ones.

Participants were tested individually, in a quiet room, seated approximately 60 cm from the screen. They were asked to rest their fingers of the left hand on two buttons of the keyboard and answer "YES" if the target was a real word (pressing the button 1 of the keyboard) and "NO" if it was a pseudoword (pressing the button 3 of the keyboard).

2.5 Data Analysis

Descriptives and inferential analyses were made. Mean RT and accuracy on the lexical decision task were analyzed with a Generalized Estimating Equations (GEE) (Liang & Zeger, 1986; Zeger & Liang, 1986). A mixed factorial design was used, with factors corresponding to group (clinical and control) as between participants variables and condition (semantic related, unrelated and pseudoword) and SOA (300 and 500 ms) as within participants variable. Educational level was controlled through covariant analyses. A significance level of .05 was adopted except for interactions analysis in which a p-value <.10 was accepted.

Latency analyses were done just with correct trials. A trial was considered an error when the participant chose the wrong answer during that lexical decision. It was also excluded trials in which the reaction time was more than 3*SD* away from the participant mean RT, because it was considered as a technical issue (Grindrod & Baum, 2003; Holderbaum & Salles, 2011). Accuracy was considered as the percentage of correct responses on each condition.

3. Results

Table 4 presents mean reaction times (RT) and accuracy corrected by educational level in each experimental condition and SOA. Concerning RT, results showed that the three-way interaction condition x group x SOA was not significant, Wald chi-square = 2.78, p = .25. Considering two-way interactions, only the interaction of condition x SOA was significant, Wald chi-square = 9.15, p = .01. Data suggest that, at the 300ms SOA, there were differences between the word (related and unrelated) and pseudoword conditions ($p < 0.001$) with faster RT for real words but no statistical difference between the related and the unrelated one ($p > .05$). It implies an absence of SPE at the 300ms SOA in both groups. Nonetheless, when the SOA was 500ms, all conditions were different among each other ($p < .05$) which confirmed the existence of SPE in both clinical and control group.

	Condition	*SOA*	*Group*	*Mean*	*Std. Error*	*Mean*	*Std. Error*
Reaction time	Rel	300	patients	1087	106	1009	64
			controls	930	58		
		500	patients	1073	88	1002	53
			controls	932	59		
	UnRel	300	patients	1125	106	1030	59
			controls	934	43		
		500	patients	1150	94	1110	55
			controls	1070	59		
	Pseudo	300	patients	1514	122	1414	70
			controls	1314	53		
		500	patients	1490	122	1388	73
			controls	1286	80		
	General		patients	1240	93		
			controls	1077	35		

	Condition	*SOA*	*Group*	*Mean*	*Std. Error*	*Mean*	*Std. Error*
Accuracy	Rel	300	patients	97	1	97	1
			controls	96	2		
		500	patients	93	2	94	1
			controls	95	2		
	UnRel	300	patients	93	3	91	4
			controls	88	7		
		500	patients	86	5	79	5
			controls	73	9		
	Pseudo	300	patients	75	6	80	4
			controls	85	5		
		500	patients	73	5	81	3
			controls	88	3		
	General		patients	86	2		
			controls	88	3		

Note. Means corrected by educational level = 8.45

Table 4 Reaction times and accuracy on the lexical decision task in the semantic priming paradigm for both groups and SOAs

Main effects of condition and SOA were not analyzed because of the interaction found between the two variables. Besides, the main effect of group was not significant (Wald chi-square = 2.84, p = .09), which indicates a pattern of performance very similar between groups.

In terms of accuracy, the three-way interaction condition x group x SOA was also not significant, Wald chi-square = 2.48, p = .29, as like the two-way interaction group x SOA (Wald chi-square = .001, p = .93). However, the two-way interactions condition x group (Wald chi-square = 4.41, p = .09) and condition x SOA (Wald chi-square = 5.54, p = .06) were statically significant. SPE was not found at the 300ms SOA, with the percentage of correct answer very similar between the related and the unrelated (p = .30). On the other hand, when the SOA was 500ms, participants were more accurate on the related condition than on the unrelated (p = .003) which consists on SPE.

Summarizing, the main results are that (in terms of RT and accuracy) neither group presented SPE when the SOA was 300ms whilst both groups showed SPE at the 500ms SOA.

4. Discussion

The purpose of the present research was to compare the SPE between patients who had suffered a stroke to the LH and their controls at two different SOAs (300ms and 500ms). Considering RT and accuracy of responses, data found suggested no differences between clinical and control groups with no SPE at the 300ms SOA and the presence of SPE at the 500ms for both groups.

The finding of similar SPE between patients and controls reported above resemble data described by Müller (2012) comparing patients who have suffered stroke to the right hemisphere (RH) and healthy controls. She used the same lexical decision task used here with a SOA of 500ms, finding SPE equally in patients and controls (Müller, 2012). The finding of SPE in patients who had suffered a stroke to the LH in lexical decision tasks with long SOAs corroborated previous works such as the one published by Prather et al. (1997) which found SPE in a Broca`s aphasic patient with SOAs longer than 1500ms. Indications that Broca`s aphasics patients could show SPE at long SOAs were also given by Mimura et al. (1996) and Hagoort (1997).

The absence of SPE at the short SOA in both groups highlighted the possibility of methodological problems. Revising literature about SPE in healthy subjects leads to the conclusion that SPE is recurrently found in adults healthy samples, both

with large and short SOAs (Nievas & Justicia, 2004; Perea & Gotor, 1997). Even though the process of lexical decision changes throughout adulthood causing slower responses but equal accuracy (Maden, 1992; Myerson et al., 1992) those changes presumably don`t affect the magnitude of the SPE (Gold, Andersen, Jicha, & Smith, 2009; Howard, 1983). For that reason, one could expect SPE in controls subjects.

Opposing to that, the evaluation of SPE in the control group of the present research didn`t show SPE at the 300ms SOA though it was present at the 500ms SOA. One of the possible methodological issues concerns the educational level of the control group. Just like researches usually use college students in studies evaluating young adults (e.g., Basnight-Brown & Altarriba, 2007; Coney, 2002; Holderbaum & Salles, 2011; Perea & Rosa, 2002), studies involving healthy aging subjects commonly create samples with high educational level as compared to ours (Balota & Duchek, 1991; Del Toro, 2000; Laver, 2009). The educational level and consequently reading proficiency can account for absence of SPE at the short SOA and the presence of it at the long one.

Another issue refers to the sample size of the present study. Given the difficulty of finding patients of the clinical group which fits the inclusion criteria, the sample of 17 participants in each group is small, especially for subsequent inferential analyses. Ultimately, a detailed assay over data analyses highlighted a possible interfering factor: the large SD found in each condition. Participants in the present study demonstrated a larger SD when compared to the other studies (e.g. Del Toro, 2000). A large *S*D demonstrates large variability in results and obliges the enhancement of the size of the sample in order to achieve a reliable effect of differences between conditions (Gravetter & Wallnau, 2011).

4.1 Final considerations

Findings of the SPE in patients who had suffered stroke to the LH are not consistent. The present study aimed to compare the SPE between patients who had suffered a stroke to the LH and their controls at short (300ms) and long (500ms) SOAs. Results showed absence of SPE at the short SOA but preserved SPE at the long SOA in both clinical and control groups. The absence of SPE in controls, which is a population in which the SPE is contundent, at the short SOA suggests methodological issues. Revising our experiment it was thought to relate to variables such as size of the sample, educational level and large SD.

Further studies should better investigate the role of educational level on the SPE once the majority of previous studies used high educated elderly on their sample. This will contribute on the comprehension of similarities and differences between normal aging and pathologies associated with age such as dementia, stroke and so far. Finally, the great variability of data found both in patients and controls cannot be ignored. Group analyses end up by removing this heterogeneity on the search for the “mean” response. Yet “mean” responses may be unrepresentative of each case and so other designs such as single case and case series should be welcome on the attempt perceive the semantic priming phenomenon.

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6. References

Balota, D.A., & Duchek, J.M. (1991). Semantic priming effects, lexical repetition effects, and contextual disambiguation effects in healthy aged individuals and individuals with senile dementia of the Alzheimer type. *Brain and Language, 40,* 181-201.

Basnight-Brown, D.M., & Altarriba, J. (2007). Differences in semantic and translation priming across languages: The role of language direction and language dominance. *Memory and Cognition, 35*(5), 953-965.

Baum, S.R. (1997). Phonological, semantic and mediated priming in aphasia. *Brain and Language, 60*(3), 347-359.

Becker, A.C. (1980). Semantic contexts effects in visual word recognition: An analysis of semantic strategies. *Memory and Cognition, 8*(6), 493-512.

Bushell, C.M. (1996). Dissociated Identity and Semantic Priming in Broca`s aphasia: How controlled processing produces inhibitory semantic priming. *Brain and Language, 55*, 264-288.

Coney, J. (2002). The effect of associative strenght on priming in the cerebral hemispheres. *Brain and Cognition, 50*, 234-241.

Del Toro, J.F. (2000). An examination of automatic versus strategic semantic priming effects in Broca's aphasia. *Aphasiology, 14*(9), 925-947.

Fonseca, R.P., Salles, J.F. & Parente, M.A.M. (2009). *Instrumento de Avaliação Neuropsicológica Breve NEUPSILIN*. São Paulo: Vetor Editora.

Fontoura, D.R., Rodrigues, J.C., Parente, M.A.P.P., Fonseca, R. & Salles, J.F. (2011). Adaptação do Instrumento de Avaliação Neuropsicológica Breve NEUPSILIN para avaliar pacientes com afasia expressiva: NEUPSILIN-Af. *Ciências & Cognição, 16*(3), 78-94. Disponível em http://www.cienciasecognicao.org/revista/index.php/cec/article/view/749

Gagnon, J., Goulet, P., & Joanette, Y. (1994). Activation of the lexical-semantic system in right-brain-damaged right-handers. In D. Hiller (Org.), *Linguistics and Cognitive Neuroscience – Teorical and Empirical Studies on Language Disorders* (pp. 33-48). Montreal (Canada): Westdeutshcer Verlag.

Gold, B.T., Andersen, A.H., Jicha, G.A., & Smith, C.D. (2009). Aging influences the neural correlates of lexical decision but not automatic semantic priming. *Cerebral Cortex, 19*, 2671-2679.

Gravetter, F.J., & Wallnau, L.B. (2011). Essentials of statistics for the behavioral sciences, Seventh Edition. Belmont, CA: Thomson/Wadsworth.

Grindrod, C.M., & Baum, S.R. (2003). Sensitivity to local sentence context information in lexical ambiguity resolution: Evidence from left and right-hemisphere-damaged individuals. *Brain and Language*, *85*(3), 503-523. doi: 10.1016/S0093-934X(03)00072-5

Hagoort, P. (1997). Semantic priming in Broca's aphasics at a short SOA: No support for an automatic access deficit. *Brain and Language, 56*, 287-300.

Holderbaum, C.S. (2009). *Efeitos de priming semântico em tarefa de decisão lexical com diferentes intervalos entre estímulos.* Dissertação de Mestrado, Universidade Federal do Rio Grande do Sul, Porto Alegre.

Holderbaum, C.S. & Salles, J.F. (2011). Semantic priming effect in a lexical decision task: Comparing third graders and college students in two different stimulus onset asynchrony. *The Spanish Journal of Psychology, 14*(2), 589-599.

Howard, D.V. (1983). The effects of aging and degree of association on the semantic priming of lexical decisions. *Experimental Aging Research, 9*, 145-151.

Laver, G.D. (2009). Adult aging effects on semantic and episodic priming in word recognition. *Psychology & Aging, 24*(1), 28-39.

Liang, K.Y., & Zeger, S.L. (1986). Longitudinal data analysis using generalized linear models. *Biometrika, 73*(1), 13-22.

Madden, D.J. (1992). Four to ten milliseconds per year: age-related slowing of visual word identification. *Journal of Gerontology, 47*, 59-68.

Meyer, D.E., & Schvaneveldt, R. W. (1971). Facilitation in recognizing pairs of words: Evidence of a dependence between retrieval operations. *Journal of Experimental Psychology, 90*, 227-234.

Milberg, W., & Blumstein, S.E. (1981). Lexical decision and aphasia: Evidence for semantic processing. *Brain and Language, 14*(2), 371-385.

Milberg, W., Blumstein, S., Giovanello, K.S.,

& Misiurski, C. (2003). Summation priming in aphasia: Evidence for alterations in semantic integration and activation. *Brain and Cognition, 51*(1), 31-47.

Mimura, M., Goodglass, H., & Milberg, W. (1996). Preserved semantic priming effect in alexia. *Brain and Language, 54*, 434-446.

Müller, J.L. (2012). Efeitos de *priming* semântico em pacientes com lesão no hemisfério cerebral direito. (Dissertação de Mestrado não publicada). Universidade Federal do Rio Grande do Sul, Porto Alegre, Brasil.

Müller, J.L., & Salles, J.F. (2013). Studies on the semantic priming effects in stroke in the right hemisphere. *Dementia & Neuropsychology, 7, 155-163.*

Myerson, J., Ferraro, F.R., Hale, S., & Lima, S.D. (1992). General slowing in semantic priming and word recognition. *Psychology and Aging, 7*, 257-270.

Naschmias, C., & Naschmias, D. (1996). *Research methods in the social sciences.* London: Arnold.

Nievas, F., & Justicia, F. (2004). A cross-sectional study about meaning access processes for homographs. *Cognitive Development, 19*, 95-109.

Perea, M., & Gotor, A. (1997). Associative and semantic priming effects occur at very short stimulus-onset asynchronies in lexical decision and naming. *Cognition, 62*, 223-240.

Perea, M., & Rosa, E. (2002). The effects of associative and semantic priming in the lexical decision task. *Psychological Research, 66*, 180-194.

Prather, P., Zurif, E., Love, T., & Brownell, H. (1997). Speed of lexical activation in nonfluent Broca's aphasia and fluent Wernicke's aphasia. *Brain and Language, 59*(3), 391-411.

Sachs, O., Weis, S., Zellagui, N., Huber, W., Zvyagintsev, M., Mathiak, K., & Kircher, T. (2008). Automatic processing of semantic relations in fMRI: neural activation during semantic priming of taxonomic and thematic categories. *Brain Research* 1218, 194–205.

Sass, K., Krach, S., Sachs, O., & Kircher, T. (2009). Lion – tiger – stripes: Neural correlates of indirect semantic priming across processing modalities. *Neuroimage*, 45, 224-236.

Salles, J.F., Holderbaum, C.S., Becker, N., Rodrigues, J.C., Liedtke, F.V., Zibetti, M., & Piccoli, L. F. (2008). Normas de associação semântica para 88 palavras do português brasileiro. *Psico (PUCRS), 39*, 260-268.

Salles, J.F., Holderbaum, C.S., Parente, M.A.M.P., Mansur, L.L., & Ansaldo, A.I., (2012). Lexical-semantic processing in the semantic priming paradigm in aphasic patients. *Arquivos de Neuro-Psiquiatria, 70*(9), 718-726.

Zeger, S.L., & Liang, K.Y. (1986). Longitudinal data analysis for discrete and continuos outcomes. *Biometrics, 42*(1), 121-130.

Zortea, M., & Salles, J. F. (2012). Estudo comparativo das associações semânticas de palavras entre adultos jovens e idosos. *Psicologia: Teoria e Pesquisa, 28 (3), 259-266.*