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The role of the prefrontal cortex in sentence comprehension: An rTMS study

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ARTICLE INFO

Article history:
Received 9 November 2005
Reviewed 12 May 2006
Revised 19 May 2006
Accepted 20 June 2006
Action editor Yves Von Cramon
Published online 23 December 2007

Keywords:
Magnetic stimulation
Memory resources
TMS
DLPFC
Semantics
Syntax

ABSTRACT

Using repetitive transcranial magnetic stimulation (rTMS), we investigated the role of the left and right dorsolateral prefrontal cortex (DLPFC) in sentence comprehension. Subjects were required to judge which of the two pictures correctly matched the meaning of active and passive semantically reversible sentences (subject–verb–object); the incorrect picture did not match the sentence in term of lexical items (semantic task) or agent–patient structure (syntactic task). The subjects performed the task while a series of magnetic stimuli were applied to the left or right DLPFC. When rTMS was applied to the left DLPFC, the subjects' performance was delayed only for the semantic task, while rTMS applied to the right DLPFC slowed the processing of syntactic information. The results of this experiment provide direct evidence of a double dissociation between the rTMS effects and the type of task, which may reflect a differential hemispheric involvement of working memory resources during sentence comprehension.

1. Introduction

The deceptively simple act of understanding the meaning of a common sentence requires a number of cognitive processes. Minimally, these include the analysis of its phonological and syntactic structure, as well as of the meaning of the composing lexical items. Sentence comprehension requires processing a sequence of words, and analyzing their syntactic and thematic organization in order to create a correct representation of the entire sentence. This elaboration needs to maintain in an activated state both single word meaning and the syntactic relations between words (Just and Carpenter, 1992). While current models of language comprehension make different predictions on the proposed time course of syntactic and semantic integration, there is general agreement about the fact that these processes require the temporary storage and manipulation of multiple classes of information (Friederici and Kotz, 2003). Both storage and manipulation are thought

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0010-9452/$ – see front matter
doi:10.1016/j.cortex.2006.06.006

to depend upon working memory (WM) resources. Behavioural experiments indicate that the comprehension of syntactically complex sentences is a demanding process, often entailing a high memory load (Turkstra and Holland, 1998; Stromswold et al., 1996; Stowe et al., 1998).

The neural mechanisms involved in sentence comprehension have been investigated by means of lesion studies and of functional neuroimaging. Lesion studies have emphasised the role of damage to perisylvian areas of the left hemisphere in sentence comprehension disorders (Caplan et al., 1996). Nevertheless it has been difficult to ascribe specific functions to discrete regions within this network. The left ventral prefrontal cortex, in particular Broca's area, has traditionally been considered to play a central role in syntactic processing (see Grodzinsky, 2000, 2006, for a comprehensive discussion). Imaging studies have provided further evidence for a central role of Broca's area in syntactic processing (Dapretto and Bookheimer, 1999; Heim et al., 2003; Moro et al., 2001; Caplan et al., 1998, 1999, 2000). During online sentence comprehension, Broca's area is important not only for syntactic integration, but also for WM mechanisms relevant for language processing (Fiebach et al., 2005). The two factors of syntactic complexity and sentence length have been often confounded in the imaging literature. Some investigations have supported the view that the inferior frontal gyrus activation is specific for syntactic processing, while the engagement of the dorsolateral prefrontal cortex (DLPFC) may reflect the WM load (Caplan et al., 2002; Hashimoto and Sakai, 2002; Walsh and Rushworth, 1999; Martin et al., 2004). A recent fMRI study, which analyzed the areas involved in a sentence judgment task, has underlined the recruitment of the dorsal portion of left frontal cortex. Specifically, this area is involved during the processing of syntactic violations associated to a large WM load (Cooke et al., 2006).

It must also be underlined that language comprehension does not involve only the left hemisphere. Less extensive activations have also been observed in right prefrontal cortex during sentence comprehension (Wartenburger et al., 2004; Moro et al., 2001; Just et al., 1996). This finding may suggest a quantitative change of the activation of prefrontal cortex due to a more demanding task (Just et al., 1996) or an engagement of other processing operations, such as visual WM resources, in order to solve a more complex task (Rapp and McCloskey, 1997).

Transcranial magnetic stimulation (TMS), a technique that can be used to map the flow of information across different brain regions during the execution of a cognitive task (Walsh and Rushworth, 1999), is another tool which can be applied to the investigation of the neural mechanisms responsible for sentence comprehension. Only one study has investigated the effects of TMS on syntactic processing (Sakai et al., 2002). In that study, a double pulse TMS was delivered to the left inferior frontal gyrus or the left middle frontal gyrus, using three possible timings (0, 150, 350 msec after target onset) during a syntactic or semantic decision task. The main finding was that during syntactic decisions there was a shortening of reaction times, but only when TMS was applied to the left inferior frontal gyrus 150 msec after target onset. There is limited additional TMS evidence for a functional role of the prefrontal cortex in language processing. A recent study highlighted a functional dissociation in left inferior frontal cortex (LIFC), with rTMS on posterior LIFC slowing homophone judgments, while anterior LIFC slowed synonym judgments (Gough et al., 2005). An involvement of left prefrontal cortex in lexical–semantic processing was demonstrated using rTMS (Cappa et al., 2002; Devlin et al., 2003).

More extensive evidence is available that repetitive TMS (rTMS) applied to the prefrontal cortex can interfere with WM tasks. With a few exceptions (Hautzel et al., 2002), most studies support a relationship between, respectively, verbal and visual stimuli, and left and right prefrontal cortex (Manoach et al., 2004; Wendt and Risberg, 2001; Johnson et al., 2003). The activation of BA 46 observed during WM task is lateralized, with a left activation for verbal stimuli and a right activation for visual stimuli (Leung et al., 2002; Rowe and Passingham, 2001; Van der Linden et al., 1999; Stern et al., 2000).

A further functional distinction can be found between the dorsal and the ventral prefrontal cortex within each hemisphere (Sala et al., 2003). There is some evidence that the left ventral prefrontal cortex is more relevant for verbal WM, whereas right dorsal prefrontal cortex is more important for the spatial WM (Walter et al., 2003). Recent TMS studies showed that verbal WM is dependent on normal functioning of the middle frontal gyrus bilaterally, suggesting that right and left-sided areas might be involved in parallel processing of different features of stimuli (Mottaghy et al., 2002a, 2003). Moreover the same authors, in a different experiment, showed that the stimulation of the DLPFC impairs performance in spatial as well as non-spatial tasks. At the same time stimulation of the dorsomedial prefrontal cortex affects only spatial tasks while stimulation of the ventral portion affects only non-spatial task (Mottaghy et al., 2002b). A recent review of TMS studies of WM highlighted the involvement of prefrontal cortex both in maintaining the transient patterns of neural activity in other areas that maintain information available online, and in executive processes (Mottaghy, 2006).

The aim of this experiment was to evaluate the relative contributions of the left and right DLPFC to sentence comprehension, by comparing the effects of rTMS applied to these two regions. The experiment involved the presentation of a sentence and two pictures (see Fig. 1). Subjects were required to judge which of the two pictures correctly matched the meaning of a semantically reversible sentence (subject–verb–object) in the active or passive form. In the syntactic condition, one picture matched the true meaning of the sentence, while in the "distracter" picture, the subject and the object of the action were reversed. In the semantic condition, the distracter did not correspond to the meaning of the sentence because the subject, object or action did not correspond to the presented lexical items. rTMS was delivered over left or right DLPFC, at a frequency of 10 Hz for a period of 900 msec, starting 100 msec after the onset of the display. The paradigm was chosen with the idea to minimise the involvement of the retention component of WM, since the information is always present to the subject, and to require the manipulation of the linguistic and pictorial information in order to allow the correct resolution of the matching task. On the basis of lesion and imaging data, we predicted a greater interference with left-sided stimulation, in particular on the syntactic task. This could be attributed to a distant effect in the ventrolateral cortex, responsible for syntactic processing, or to a direct effect on the manipulation component of WM.

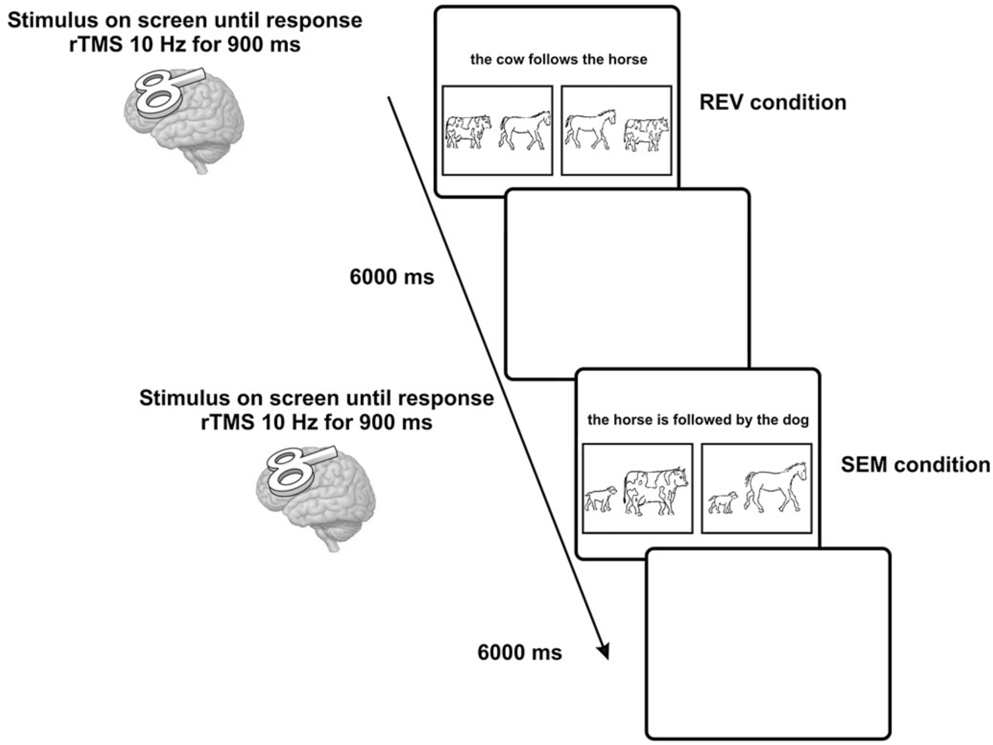

Fig. 1 – Presentation of stimuli and rTMS paradigm. rTMS was delivered 100 msec after the onset of the display, which was composed of a sentence and two pictures, and lasted 900 msec (10 stimuli). Participants were instructed to press a left or right key according to the location of the picture consistent with the sentence. The display stayed on the screen until the subject gave a response.

2. Methods

2.1. *Subjects*

A group of 12 subjects (mean age = 27.33 years; mean education = 17.67 years) participated in the experiment. All subjects were native Italian speakers and had normal or corrected-to-normal visual acuity. Participants reported being free of neurological disorders or history of seizures. All were right handed, with a mean score on the Edinburgh Handedness Inventory of +81.33. Participants were informed about the possible risk of rTMS and informed consent was obtained after a safety screening. The experimental methods had ethical approval from the local Human Ethics Committee.

2.2. *Stimuli*

The stimuli had been selected from the oral and written sentence comprehension task in the ‘‘Batteria per l’Analisi dei Deficit Afasici – B.A.D.A.’’ (Miceli et al., 1994). A sentence and two pictures made up each display. All sentences were made up of two noun phrases and one verbal phrase (i.e., ‘‘la mucca segue il cavallo’’ ‘‘the cow follows the horse’’), with a mean length in letters of 26.71 (range 21–37) and a mean length in words of 5.56 (range 5–7). All the experimental sentences and their translations are reported in the Appendix. The stimuli were presented in black lower-case letters (Times New Roman font size 30) on a white background.

A total of 58 sentence–picture pairs were constructed: 48 for the three experimental blocks (16 for each one), and 10 for the practice session. The subjects’ task was to match the sentence with one of the two pictures. The ‘‘distracter’’ picture could be of two different types: (1) in the semantic condition, ‘‘SEM’’, for the sentence ‘‘the horse is followed by the dog’’ (il cavallo è seguito dal cane) the wrong picture depicted a *cow* followed by a dog; (2) in the syntactic condition, in which the sentence was reversible, ‘‘REV’’, for the sentence ‘‘the cow follows the horse’’ (‘‘la mucca segue il cavallo’’) a wrong picture could depict a horse following a cow. In the latter type of trials, morpho-syntactic information is crucial because the subject must correctly comprehend the structure of the sentence to solve the task correctly. Failure to respond correctly to ‘‘REV’’ trials would seemingly indicate a failure to process morpho-syntactic information. In the SEM condition, the crucial information could have been in one of the two noun phrases (e.g., a wrong picture could depict a *cow* followed by a dog or a horse followed by a *cat*), or in the verbal phrase (e.g., the wrong picture depicts a horse *frightened* by a dog). The two pictures used in a trial were always different along one of the two possible dimensions (SEM and REV), and in all the trials there was only one picture that correctly matched the sentence. Each block contained an equal number of SEM and REV trials, presented in a pseudo-random order, and in each condition sentence form (active or passive), position of the relevant information (the first or the second noun phrase or the verb phrase for the semantic condition), and position of the correct picture (left or right), as well as stimulation site (left, midline sham or right rTMS), were counterbalanced.

2.3. Procedure

Subjects sat in a dimly lit room facing a computer monitor. The stimuli were presented using Presentation software (Version 0.70, www.neurobs.com) running on a personal computer with a 17-inch screen. At the beginning of each trial, one sentence and two pictures were presented. The sentence was located at the top of the screen above the two pictures, which were on the left and right side of the screen (see Fig. 1). The subjects were asked to judge which of the two pictures was an accurate representation of the sentence. Subjects made a speeded decision via a two-choice button press, using both hands. The visual stimulus stayed on the screen until a response was given and a blank screen lasting 6000 msec was interspersed between trials. The whole session, including preparation, lasted about 40 min.

2.4. rTMS procedure

rTMS was applied using a Magstim Rapid with a figure-of-eight (double 70 mm) coil which can induce a maximum magnetic field of 2.2 T at the scalp site. Before the experiment, individual resting motor excitability thresholds of stimulation were determined by stimulating the left motor cortex and inducing a contraction evoked by a single TMS pulse in the contralateral first interosseus dorsalis muscle. The threshold was defined as the minimum intensity that induced a visible contraction in the tested muscle, as agreed by two experimenters on at least three out of six trials. The stimulation intensity used during the experiment was set at 90% of each subject's threshold. The mean stimulation intensity was 56.7% (min. 48%, max. 65%) of the maximum of the stimulator output. During the experiment, rTMS was delivered using a train of 10 pulses with a frequency of 10 Hz (i.e., lasting a total of 900 msec), starting 100 msec after trial onset. On the basis of evoked response studies, this was chosen as an ideal time window for interference with sentence comprehension task (Hald et al., 2006; Eckstein and Friederici, 2005; Haarmann and Cameron, 2005; Haarmann et al., 2005). Moreover, we decided to use a 10 Hz frequency to reduce the amount of overall stimuli delivered to each subject. This line of reasoning was based on the aim to keep stimulation on a safe side as much as possible (Wassermann, 1998).

Although individual radiological head images (i.e., magnetic resonance images – MRIs) were not available for our subjects, we localized left and right DLPFCs using the SofTaxic Evolution navigator system (Version 1.0, www.emsmedical.net). This system allows the reconstruction of cerebral cortex in Talairach coordinates, with an accuracy of ~1 cm, on the basis of digitized skull landmarks (nasion, inion and two preauricular points) from which 50 uniformly distributed points can be mapped out on the scalp (3D Fastrak Polhemus digitizer) and then can be related to cerebral anatomy. An estimation of the single subject's cerebral volume is obtained by "Point-based Warping" to a MRI template and a 3D virtual reconstruction based on the points recorded from the subject's scalp.

This method represents a good and cost-effective solution when single subject MRI scans are not available. It should be noted however that, while we can compute with very high precision the location of the coil, this does not strictly imply that we know the precise cerebral areas that are directly influenced by the magnetic field. Therefore, we can only assume that we were stimulating the estimated cortical site underlying the coil.

Using this system, we localized in each subjects the posterior region of BA 46 (Talairach coordinates $X = \pm 49$, $Y = 36$, $Z = 25$, middle frontal gyrus) at about halfway between F3/4 and F7/8, respectively, in the 10/20 EEG system. The subjects wore a close-fitting skullcap on which these positions were reproduced. To stimulate DLPFC, we placed the anterior end of the junction of the two coil wings above this location marked on the skullcap.

The experiment included three blocks corresponding to three stimulation sites: left and right, which were estimated to overlie the left and right DLPFCs, and sham. The stimulation site for the sham condition was on the midline in the same coronal plane at the same horizontal level as the frontal sites but the coil being perpendicular to the scalp, thus ensuring that no effective magnetic stimulation reached the brain during the sham condition. Several approaches could be used to try to ensure that changes in performance are attributable specifically to the effects of TMS upon the brain. We decided to use both sham stimulation, as a baseline condition, and the stimulation of two homologous areas to compare the effects of rTMS upon different sites. Moreover, in our study we have also taken the approach of observing behaviour across two distinct tasks following the stimulation of one site (e.g., Beckers and Zeki, 1995). This technique is often used to try to ensure that effects of TMS are specifically due to the modulation of selected brain areas too.

3. Results

In order to assess the effects of site of stimulation on the two conditions, we analyzed accuracy and reaction time (RT) by means of repeated measures ANOVAs. Since the interaction between condition, site of stimulation and sentence form (active or passive) was not significant [$F(2,22)=2.368$; $p > .12$], the data from the passive and active conditions were combined. Thus, in these analyses, the two factors were *condition* (semantic, SEM and syntactic, REV) and *site of stimulation* (left DLPFC, right DLPFC and sham rTMS). Analysis of accuracy [mean = 87.15%; semantic = 87.16% (left = 84.4%, right = 86.5%, sham = 90.6%); syntactic = 86.80% (left = 86.5%, right = 89.6%, sham = 84.4%)] showed no differences between main factors nor significant interactions.

The RT analysis was performed only on correct responses that were less than two standard deviations from the mean RT (the 3% of the responses was eliminated). No significant differences were present for the two main factors [*condition*: $F(1,11) = .233$, $p > .05$; *site of stimulation*: $F(2,22) = .053$, $p > .05$], but there was a significant interaction between them

[$F(2,22) = 9.623$, $p = .001$], indicating a differential effects of the site of stimulation in the two conditions. This analysis was followed by planned comparisons (*t*-tests). As can be seen from Fig. 2, these comparisons confirmed that in the SEM condition stimulation of the left DLPFC slowed RTs (2744 msec) more than sham (2509 msec) or right (2429 msec) stimulation [left vs. sham: $t(11) = 2.111$, $p = .05$; left vs. right: $t(11) = 2.956$, $p = .013$]; while in the REV condition stimulation of the right DLPFC slowed RTs (2691 msec) more than left (2519 msec) or sham (2517 msec) stimulation. In this second set of analyses, the comparison between right and sham stimulation was significant [$t(11) = 2.449$, $p = .032$] and the difference between left and right stimulation approached significance [$t(11) = 1.847$, $p = .092$]. No other effect reached significance.

4. Discussion

Our study was designed to evaluate the involvement of the left and right DLPFC in understanding semantically reversible active and passive sentences. The main result is a double dissociation of interference effects: rTMS applied to the left DLPFC slowed the performance in the lexical–semantic task; in contrast, rTMS applied to the right DLPFC slowed the performance in the syntactic task.

These results were not predicted on the basis of the lesion and imaging evidence. A disorder of syntactic comprehension is usually associated to agrammatic Broca's aphasia, due to lesions involving the left ventrolateral prefrontal cortex. Lexical–semantic comprehension impairments are typically found in patients with left post-rolandic damage.

This apparent discrepancy may be an example of the fallacy of the ''virtual lesion'' interpretation of TMS effects. The mechanism of action of TMS is to induce electric currents that produce excitation or inhibition in restricted pools of superficial cortical neurons underneath the coil. In the last few years, the combined use of TMS and functional imaging techniques has allowed the investigation of TMS influence on the underlying cortical areas. In a combined rTMS–PET study, Mottaghy et al. (2000) demonstrated that rTMS to the right or left DLPFC can worsen performance in a verbal WM task while inducing significant reductions in rCBF both at the stimulation site and at distant brain regions. These results underlined the ability of rTMS to produce temporary functional modulations of a neuronal network involved in the selected behavioural task that result in a modification of subjects' performance. Therefore, it is reasonable that the effects highlighted in rTMS studies cannot be totally and directly compared with lesion studies. Nevertheless, the effects of TMS in the cognitive neuroscience field have often been interpreted as the consequence of a transient lesion, which may avoid problems related to cortical plasticity, functional reorganization, individual differences on subject ability or lesion localization. However, the use of TMS as an interference tool has never produced a clear deficit in the subject performance, like in patients. The type of effect is often related on increased timing in the information processing (e.g., increased reaction time) and, if a reduction of subject performance is recorded, it is most likely explained by the complexity of the processing needed to solve the task; for that reason the effect of TMS may be related to the reduction of the difference between the signal and the noise present in the system. Therefore, TMS can be regarded as an interference method that can increase the timing for the information processing or modify criteria for response decision.

With these considerations in mind, we can attempt an interpretation of the hemisphere-specific interference effects.

In the semantic condition, the subject had to compare two noun phrases and one verb phrase with their possible pictorial representations. This task requires the retention and the manipulation of lexical–semantic information in WM. Hanten and Martin (2001), Martin and Romani (1994), Martin et al. (1994, 1999) have argued that the span tasks usually adopted to measure verbal WM tap both phonological and semantic retention. The phonological component of span tasks is independent of the capacity involved in sentence processing, as indicated by the neuropsychological observations of patients with difficulty retaining phonological information who nevertheless show preserved sentence comprehension. In contrast, the semantic component plays a crucial role in sentence comprehension in the maintenance of word meanings prior to their integration with other word meanings. Patients with a semantic retention deficit are impaired in detecting the presence of a semantic anomaly in sentences with multiple adjectives preceding a noun (e.g., ''The wooden big black coat'') or with several nouns preceding a verb (e.g., ''Priests, melons and cherries can be usually bought in shops''). The same patients' performance improved when the adjectives followed the noun or the nouns followed the verb.

A specific role of left prefrontal cortex in the manipulation of semantic information is supported by recent lesion findings. A study evaluating a large number of left hemisphere injured patients, found that lesions of middle and superior temporal gyrus, mid-frontal cortex in Brodmann's area 46 and Brodmann's area 47 of the inferior frontal gyrus affected comprehension performance evaluated with the Curtis–Yamada Comprehensive Language Evaluation (Curtiss and Yamada, 1988), while lesions of Broca's and Wernicke's areas did not significantly modify language comprehension evaluated with this test (Dronkers and Ogar, 2004).

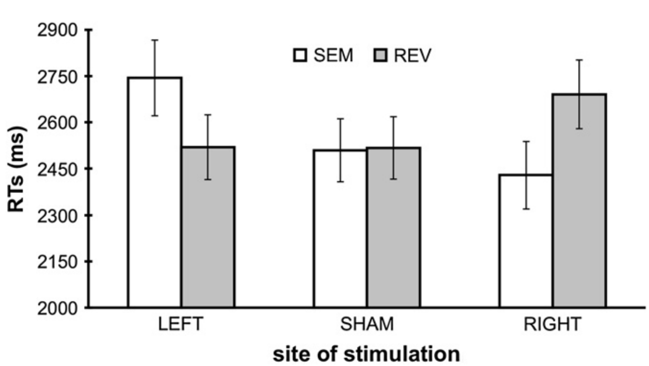

Fig. 2 – Behavioural results of the experiment. The graph shows reaction times for the three stimulation sites (left, sham and right rTMS), and the two conditions (semantic, SEM and syntactic, REV). As can be seen, rTMS to the left slowed RTs in the SEM condition while rTMS to the right slowed RTs in the REV condition. Vertical bars represent standard errors of the mean.

In the syntactic condition of the experiment, the participants had to create a representation of the meaning of the entire sentence, which resulted in the identification of the thematic roles of the lexical items (agent and subject) on the basis of a syntactic analysis, and to compare it with the two presented pictures. This process was prone to interference by right-sided, rather than by left-sided rTMS to the middle frontal gyrus. As pointed out in Section 1, this is an area which is considered to play an important role in the manipulation of spatial information in WM (Leung et al., 2002; Rowe and Passingham, 2001; Van der Linden et al., 1999; Stern et al., 2000; Koch et al., 2005), and thus its role in sentence comprehension was unexpected. The idea of a possible involvement of spatial processes in language understanding can be traced back to Luria's interpretation of the syndrome of semantic aphasia (Luria and Hutton, 1977), characterized by the defective comprehension of logic-grammatical structures, as due to a disturbances of ''simultaneous, spatial schemes''. More recently, it has been proposed that the mapping of grammatical categories (subject, object) onto thematic roles (agent, patient) may be based on spatial representations, and thus be particularly sensitive to right hemispheric damage. Some clinical observations support this idea (Chatterjee et al., 1995a, 1995b; Warrington, 2000). The hypothesis that the logical structure of a sentence, independent of its syntactic structure, is represented in space according to a left-to-right ''language line'' is supported by the recent observation that patients affected by hemi-inattention tend to neglect the position of the subject noun phrase in sentence presented auditorily. This is in the left part of the sentence in the case of actives, but on the right side for passive sentences (Rinaldi and Pizzamiglio, 2006).

It is noteworthy that in the case of imaging studies, an increase in ''complexity'' of a sentence, both in terms of syntactic structure and of WM requirements, has been associated with more extensive brain activation, extending to the right hemisphere (Just et al., 1996). The recruitment of right-sided areas has been associated with the processing of visuo-spatial content (Drummond et al., 2003; Carpenter et al., 1999).

In conclusion, we propose an interpretation of the observed double dissociation in term of interference with specific WM resources, related to each hemisphere. In particular, in the case of the semantic condition, left TMS had an influence on subjects' performance since it interfered with verbal WM, while in the case of syntactic condition right TMS slowed participants' performances since it interfered with visuo-spatial memory during sentence–picture matching. In particular, since we minimized the involvement of the retention component, these effects may be attributed to an interference with the manipulation of semantic or syntactic information.

Appendix

Experimental sentences

Active	Passive
Syntactic condition	
i gatti inseguono i cani	il cavallo è inseguito dal cane
(the cats chase the dogs)	(the horse is chased by the dog)
la macchina segue il camion	il nonno è seguito dal bambino
(the car follows the lorry)	(the grandfather is followed by the child)
le mamme baciano i bambini	le bambine sono applaudite dal bambino
(the mothers kiss the children)	(the girls are applauded by the boy)
le moto hanno superato le macchine	la cartella è coperta dai libri
(the motorcycles outpaced the cars)	(the bag is covered by the books)
il cavallo spaventa le bambine	le bambine sono precedute dai bambini
(the horse frightens the girls)	(the girls are preceded by the boys)
le donne spingono gli uomini	i topi sono spaventati dai nonni
(the women push the men)	(the mice are frightened by the grandfathers)
le mamme accarezzano le bambine	la macchina è inseguita dalla moto
(the mothers caress the girls)	(the car is chased by the motorcycle)
i gatti inseguono i palloni	le donne sono inseguite dagli uomini
(the cats chase the balls)	(the women are chased by the men)
le moto hanno superato la macchina	i topi sono assaliti dai gatti
(the motorcycles exceeded the car)	(the mice are assailed by the cats)
il ladro insegue il poliziotto	la mamma è pettinata dal bambino
(the robber chases the policeman)	(the mother is combed by the child)
la moto ha superato la macchina	i ladri sono inseguiti dai poliziotti
(the motorcycle exceeded the car)	(the rubbers are chased by the policemen)
l'autobus segue la macchina	le ballerine sono applaudite dal bambino
(the bus follows the car)	(the dancers are applauded by the boy)
Semantic condition	
la moto insegue la macchina	il nonno è indicato dal bambino
(the motorcycle chases the car)	(the grandfather is pointed by the child)
il bambino indica la donna	le bambole sono pettinate dalle bambine
(the boy points to the woman)	(the dolls are combed by the girls)
l'uomo pettina la bambina	il nonno è accompagnato dal ragazzo

Experimental sentences (*continued*)

Active	Passive
(the man combs the girl)	(the grandfather is accompanied by the boy)
le bambine pettinano i bambini	la macchina è preceduta dall'autobus
(the girls comb the boys)	(the car is preceded by the bus)
i nonni accompagnano la bambina	l'autobus è tirato dal camion
(the grandfathers come with the girl)	(the bus is dragged by the lorry)
i cani inseguono i gatti	la moto è stata superata dalla macchina
(the dogs chase the cats)	(the motorcycle is exceeded by the car)
il medico saluta il bambino	i nonni sono spaventati dai gatti
(the physician says goodbye to the boy)	(the grandfathers are frightened by the cats)
il cavallo insegue il cane	gli uomini sono spinti dalle donne
(the horse chases the dog)	(the men are pushed by the women)
i bambini applaudono le ballerine	i conigli sono spaventati dai gatti
(the boys applaud the dancers)	(the rabbits are frightened by the cats)
la bambina abbraccia le ballerine	il ladro è inseguito dal poliziotto
(the girl hugs the dancers)	(the robber is chased by the policeman)
i pagliacci fischiano al cantante	il camion è spinto dall'autobus
(the clowns clap the singer)	(the lorry is pushed by the bus)
le donne inseguono gli uomini	il bambino è seguito dal nonno
(the women chase the men)	(the child is followed by the grandfather)

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