Manipulating hemispheric attentional mechanisms to modulate word retrieval in aphasia

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Published online: 15 Sep 2011.

To cite this article: Sophia J. van Hees, Erin R. Smith & David A. Copland (2011): Manipulating hemispheric attentional mechanisms to modulate word retrieval in aphasia, Aphasiology, 25:12, 1469-1487

To link to this article: http://dx.doi.org/10.1080/02687038.2011.583989

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Manipulating hemispheric attentional mechanisms to modulate word retrieval in aphasia

Sophia J. van Hees, Erin R. Smith, and David A. Copland

The University of Queensland, Centre for Clinical Research and School of Health and Rehabilitation Sciences, Brisbane, Australia

**Background:** Emerging evidence suggests that left hemisphere damage may create an attentional bias towards stimuli initially processed in the right hemisphere.

**Aims:** The current study aimed to investigate whether this hemispheric attentional bias influences spoken word production in a picture–word interference task.

**Methods & Procedures:** Two participants with aphasia and seven healthy controls named centrally presented pictures that were preceded by a distractor word which appeared in either the left or right visual field 200 ms prior to the picture. Distractor words were semantically related, phonologically related, unrelated, or the name of the picture. Results were analysed in terms of response times and accuracy.

**Outcomes & Results:** A greater overall facilitation effect was found in the left visual field/right hemisphere condition for both participants with aphasia, however this varied depending on distractor condition. These results are consistent with an attentional bias towards linguistic stimuli initially presented to the right hemisphere. In contrast, the results of the control group suggest a reduction in the lateralisation of language processing to the left hemisphere in healthy ageing.

**Conclusions:** These results suggest that spoken word production may be influenced by changes in attentional mechanisms following left hemisphere damage in aphasia, as well as changes in hemispheric lateralisation and inhibition in healthy ageing. Identifying attentional conditions that optimise language performance in aphasia may have implications for new treatments in language rehabilitation.

**Keywords:** Anomia; Stroke; Rehabilitation; Divided visual field; Hemispace; Picture–word interference.

The investigation of language impairments in aphasia has predominantly focused on breakdowns at the linguistic level. However, emerging evidence suggests that attentional factors also contribute to the symptoms of people with aphasia, and may in some circumstances be a better predictor of language treatment success than baseline language performance (Erickson, Goldfiner, & LaPointe, 1996; Fillingham, Sage, & Lambon Ralph, 2006; Petry, Crosson, Gonzalez Rothi, Bauer, & Schauer, 1994). Despite this, there is limited research on the relationship between attention...
and aphasia, and what attentional conditions may facilitate language performance in aphasia rehabilitation. Specifically, differences in attentional mechanisms following left hemisphere damage may produce a processing advantage for linguistic stimuli initially processed in the right hemisphere for people with aphasia, dependent on the type of linguistic stimuli presented (Coslett, 1999); however, this possibility has not been explored with respect to different aspects of spoken word production.

A common method employed in research investigating attention and language is the dual-task paradigm. With respect to the limited-capacity theory of attention, decreased performance during dual tasks has provided evidence that language functions are impacted by attentional capacity (Coslett, 2000). One such dual task is the naming of pictures in the presence of distractor words. Studies that have examined picture–word interference tasks in healthy participants have found differing effects depending on the type of distractor word, as well as the timing of distractor presentation. Either interference or facilitation of naming, as measured by a decrease/increase in the speed and accuracy of naming relative to a picture-alone condition, has been found depending on whether distractor words are semantically or phonologically related, as well as whether distractor words are presented before, during, or after picture presentation (e.g., Lupker & Sanders, 1982). A facilitation effect, or increase in the speed and/or accuracy of naming, is often found when phonologically related words are presented simultaneously with or immediately following picture presentation (Ferreira & Pashler, 2002; Melinger & Rahman, 2004; Schriefers, Meyer, & Levelt, 1990; Wilshire, Keall, Stuart, & O’Donnell, 2007). In contrast, an interference effect, or decrease in the speed and/or accuracy of naming, is often observed when semantically related distractor words appear immediately prior to picture presentation (Ferreira & Pashler, 2002; Lupker & Sanders, 1982; Melinger & Rahman, 2004; Schriefers et al., 1990; Wilshire et al., 2007).

Such discrepancies between interference and facilitation effects of distractor words in picture–word interference tasks, depending on the relatedness of the distractors as well as the timing of distractor presentation, have been used to examine models of spoken word production. The majority of such models describe a spread of activation between two main stages of word production; the retrieval of the semantic information required for word production, which in turn spreads to the retrieval of the phonological word form to determine the subsequent articulatory plan for word production (e.g., Dell, Schwartz, Martin, Saffran, & Gagnon, 1997; Levelt, 1989, 2001). Thus, when semantic distractor words appear prior to or at the same time as a picture to be named, a decrease in the speed and accuracy of naming is thought to reflect interference due to competition arising between representations at the semantic or lexical retrieval stages (but see Finkbeiner & Caramazza, 2006). In contrast, when phonological distractor words appear simultaneously with or soon after picture presentation, an increase in the speed and accuracy of naming is thought to reflect activation of the lexical representation of the target by the phonological distractor possibly due to shared phonology (Damian & Martin, 1999).

Although the effects of distractor word presentation on naming performance has been investigated in young healthy participants, very few studies have examined how picture–word interference tasks are performed in people with aphasia subsequent to left hemisphere stroke. Rogers, Jones Redmond, and Alarcon (1999) compared participants with aphasia with and without concomitant apraxia of speech (AOS) using an auditory picture–word interference paradigm. Both groups displayed interference of picture naming from semantic distractors that preceded interference from...
phonological distractors; however, the group with concomitant AOS showed an extended duration of semantic interference, as well as a later onset of peak phonological interference, suggested to represent prolonged semantic activation in the AOS group. Another study conducted by Hashimoto and Thompson (2010) used a picture–word interference paradigm with a group of 11 participants with predominant impairments at the level of access to the phonological system. The authors interpreted semantic interference effects as indicating a disruption at the level of post-lexical phonological processing, and phonological facilitation effects as indicating a disruption at the level of phonological encoding.

In contrast to Hashimoto and Thompson (2010), a case study conducted by Wilshire et al. (2007) reported facilitation of naming from semantic distractor words. This result was thought to relate to prolonged semantic processing in this individual, and suggests that semantic distractors may facilitate naming when there is a deficit at the level of semantic processing required for word production by increasing semantic activation. However, semantic distractors may interfere with naming when there is a deficit at the level of lexical selection, by creating increased competition. Alternatively, semantic interference may also represent impairment in the inhibitory mechanism required to ignore the distracting stimuli (Wiener, Tabor Connor, & Obler, 2004).

Other studies employing dual tasks to investigate attentional mechanisms in people with aphasia have found greater interference in dual-task conditions for people with aphasia than non-brain-damaged controls (Caplan & Waters, 1994; LaPointe & Erickson, 1991; Murray, Holland, & Beeson, 1998). This finding has been attributed to a decrease in attentional capacity, as both tasks are effectively competing for the same limited resources. Alternatively, attentional impairments in aphasia may stem from an inability to distribute resources appropriately (McNeil, Odell, & Tseng, 1991; Tseng, McNeil, & Milenkovic, 1993). From this perspective, the performance of people with aphasia during dual tasks represents a deficit in the allocation of attentional resources to multiple tasks, as opposed to decreased capacity of the system.

Although the underlying cause of attentional impairments in aphasia remains controversial, conditions that improve attentional function may have implications for the rehabilitation of language in aphasia. Several studies have examined the effect of hemispace on attention and language processing following left hemisphere lesions (Coslett, 1999; Crosson et al., 2005; Dotson et al., 2008; Robin & Rizzo, 1989). The term hemispace refers to the side of space relating to either hemisphere, where the left side of a central fixation point correlates to the left hemispace, and the right side to the right hemispace. Coslett (1999) observed improved performance when participants with left parietal lesions (with or without aphasia) responded to language stimuli presented predominantly in the left hemispace compared to the right. Crosson et al. (2005, 2007) and Dotson et al. (2008) employed a naming treatment with an attentional component where pictures were presented in the left hemispace. Most participants showed improved performance, although a comparison condition of contralesional presentation was not employed.

In order to investigate hemispatial effects on language performance, the above studies have required participants to turn their head to direct attention to a particular hemispace. This methodology is limited because it fails to restrict stimulus presentation to one visual field or hemispheric attentional system, which is likely to influence the results of the study. A more systematic method to examine hemispheric attentional mechanisms is to use divided visual fields (Graves, 1983). Using this method,
stimuli presented to one visual field would be initially processed by the contralateral hemisphere. Specifically, stimuli presented in the left visual field would be initially processed by the right hemisphere, and vice versa. Thus, any differences found between visual field presentations are likely to reflect differences in early hemispheric functions (Bourne, 2006).

Divided visual field methodology has been employed in research conducted by Petry et al. (1994), who examined the ability of people with aphasia to orient attention to the left and right of a central fixation point. Consistent with the research examining hemispace effects, people with aphasia were slower to respond to targets in the right visual field. However, such differences between visual field presentation and attentional mechanisms were not extended to the processing of linguistic information in this study. The use of divided visual field presentation of a linguistic task that places demands on attentional mechanisms, such as picture naming in the presence of distractor words, would allow for investigation into the effect of hemispheric attentional mechanisms on language performance, as well as how this may be affected in people with aphasia following left hemisphere damage.

The combination of picture–word interference tasks and divided visual field methodology has been employed in studies investigating healthy participants, where differing amounts of interference and facilitation effects have been found depending on the relatedness of the word and the visual field in which it was presented. Such discrepancies between visual field presentation and distractor relatedness may relate to differences in the initial processing of linguistic information between the two hemispheres. For example, Lupker and Sanders (1982), found semantic distractors to cause the most interference in the right visual field, compared with unrelated words, pronounceable non-words, and consonant strings. Such effects may reflect interference during the semantic activation stage of word production when words are initially processed in the left hemisphere. In contrast, no differentiation was found between each condition with left visual field presentation. Thus, the presence of a letter string determined the interference effect irrespective of the linguistic nature of the distractor when initially processed in the right hemisphere.

The aim of the current study was to examine whether there is a hemispheric attentional bias during spoken word production in people with aphasia, using a picture–word interference task with distractors presented using a divided visual field paradigm. Distractors included phonologically or semantically related words, as well as the name of the target word for repetition. An unrelated word condition was employed as a control condition for comparison, as it is assumed that unrelated words will not contain any overlapping or competing processes with the target word. Thus enhanced performance compared to the unrelated condition would reflect facilitation of naming, whereas slower or less accurate performance would reflect interference.

Of interest is whether an attentional bias for stimuli initially processed in the right hemisphere in people with aphasia extends to the facilitation/interference of spoken word production. Based on the findings of studies investigating hemispatial effects in individuals with left hemisphere lesions, it is predicted that there will be a processing advantage for linguistic information from the left visual field for participants with aphasia. A comparison of results across distractor conditions will determine whether different aspects of spoken word production are impacted by hemispheric attentional bias in individuals with aphasia.
METHOD

Participants
Two participants with chronic aphasia post-stroke completed the experiment. The presence of aphasia was defined as an impairment in language following damage to the brain and not due to developmental or cognitive impairments; such impairments include difficulty in production or comprehension of language, as well as reading, writing, and repetition (Goodglass & Wingfield, 1997). Both participants displayed impairments in either language comprehension or production, as demonstrated by below normal performance on subtests of the Western Aphasia Battery (WAB) or Boston Diagnostic Aphasia Examination (BDAE) (see Table 1).

Both participants were male, right-handed, with normal hearing and normal or corrected-to-normal vision. The first participant, S1, was diagnosed with aphasia following a left hemisphere stroke; however information regarding the specific lesion site was not available at the time of the study. S1 was 61 years of age, had an education level of 10 years, English as a first language, and was 8 years post-onset of aphasia at the time of the study. S1 had no reported paralysis or neglect, no apparent apraxia of speech, and no other reported neurological disease/disorder. No results of cognitive assessment were available for S1; however S1 did not have a diagnosis of cognitive impairment or any reported changes in cognitive functioning. Results of language assessment at 2 years, 5 months post onset were consistent with anomia,

<table>
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<tr>
<th>Assessment: SI</th>
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<th>Assessment: S2</th>
<th>Subtest score</th>
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<tr>
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<td>BDAE:</td>
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<tr>
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<td>Word Comprehension</td>
<td>36/37</td>
<td>70</td>
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<td>Yes/No Questions</td>
<td>54/60</td>
<td>Commands</td>
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<td>36/80</td>
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<td>Single words</td>
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<td>50</td>
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<td>Sentences</td>
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<td>Naming:</td>
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<tr>
<td>Sentence completion</td>
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<td>Responsive naming</td>
<td>20/20</td>
<td>100</td>
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<td>Screening of special categories</td>
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<td>Naming in categories:</td>
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<td>32/60</td>
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<td>Actions</td>
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*WAB = Western Aphasia Battery; BDAE = Boston Diagnostic Aphasia Examination; BNT = Boston Naming Test; MMSE = Mini Mental State Examination.
with primary deficits in naming and word finding, displaying both phonological and semantic paraphasias.

The second participant, S2, was diagnosed with aphasia following a left MCA stroke. MRI scan showed S2’s lesion to involve ex vacuo dilation of the left lateral ventricle and encephalomalacia in the left insula and left parieto-occipital region. S2 was 58 years of age, had an educational level of 12 years, and was 2 years post stroke at the time of the study, a significantly shorter time post-onset than S1. S2 acquired English at the age of 7, his first language being Dutch, with English now his primary language. S2 had no reported paralysis or neglect, no apparent apraxia of speech, and no other reported neurological disease/disorder. Cognitive screening assessment revealed S2 to be within the normal range. Although not able to be classified into one of the classical subtypes of aphasia, S2 had recovered from a global type aphasia, however he continued to show problems with receptive language, as demonstrated in language assessments administered following completion of the current experiments.

A total of seven healthy control participants (three male, four female) also completed the experiment. Control participants ranged from 53 to 83 years of age ($M = 67.71, SD = 12.54$) with a mean educational level of 14.86 years ($SD = 4.49$). All participants were right-handed, according to the Edinburgh Handedness Inventory (Oldfield, 1971) and had normal or corrected-to-normal vision. None of the control participants had any history of neurological disorders, head trauma, substance abuse, psychiatric disorders, or developmental speech/language disorders. Prior to the commencement of the experiment, informed consent was obtained in writing from all participants. Ethical approval for this project was obtained from the School of Health and Rehabilitation Sciences at the University of Queensland.

**Materials and design**

A total of 120 pictures were selected from the International Picture Naming Project (IPNP) database (Szekely et al., 2004). Pictures were divided into four groups of 30 and each group was then assigned to a distractor word condition. The four conditions included semantic distractors (SEM), which were both categorically and associatively related; phonologically related distractors (PHON); unrelated distractors (UNR); and a repetition condition (REP). From the 30 distractor words in each of the four conditions, 15 distractor words were assigned to the left visual field and 15 to the right visual field, creating eight conditions under investigation. There were no significant differences between the number of syllables, number of characters, name agreement, visual complexity, and age of acquisition (Szekely et al., 2004) of pictures in these groups ($p > .05$).

The stimuli for the semantically related condition contained fewer than eight graphemes, were in the same semantic category according to the IPNP database, and appeared as associates in the Edinburgh Association Thesaurus (Wilson, 1988). No significant differences were found in terms of semantic categories, number of syllables, number of characters, and imageability (Szekely et al., 2004), of semantic distractors presented in either visual field ($p > .05$). Additionally there was no significant difference between the latent semantic analysis scores, a measure of semantic neighbourhood density (Landauer, 1998), or associative frequency (Wilson, 1988) of semantic distractors presented in either visual field ($p > .05$).
Phonologically related stimuli were obtained from the MRC psycholinguistic database (Wilson, 1988). Words containing the same initial two phonemes, and which were fewer than eight graphemes, were chosen as phonological distractors. No significant differences were found in terms of semantic categories, number of syllables, number of characters, and imageability (Szekely et al., 2004) of phonological distractors presented in either visual field ($p > .05$). Additionally, there was no significant difference between the phonological neighbourhood densities (Balota et al., 2007) of phonological distractors presented in either visual field ($p > .05$).

Unrelated distractors were selected from the IPNP database. These items were not in the same semantic category and were not phonologically related to the target picture. No significant differences were found in terms of semantic categories, number of syllables, number of characters, or imageability (Szekely et al., 2004) of unrelated distractors presented in either visual field ($p > .05$). The pictures to be named were different for each condition to avoid repetition effects between distractor word conditions and hemispheric presentation. See Appendix for the lists of stimuli used.

**Apparatus**

The picture stimuli were presented centrally as black line drawings on a white background on a Dell Latitude D800 Pentium M computer, using E-Prime Experimental Software version 1.1.2 (Psychology Software Tools, 2002). Responses were measured with an Audio Technica ATR20 microphone connected to an SRB200-03292 serial response box with millisecond accuracy. Distractor words were presented on either the left or right side of the screen in black lowercase Times New Roman 22-point font. A chin rest was used to limit head movement and ensure distractor words were being presented to one visual field.

**Procedure**

The experiment was conducted in each participant’s home in a quiet, well-lit room. Participants were seated with the chin rest approximately 30 cm from the computer screen. The experiment was preceded by a picture-naming task using the same picture items without the distractor words. This aimed to familiarise participants with the pictures and their correct names. If participants responded with a name different from the expected name they were corrected, as per typical picture–word interference tasks (e.g., Schriefers et al., 1990). Participants were informed that they would be required to name the same series of pictures with words presented on either the left or right side immediately before picture presentation.

The experiment consisted of 10 practice trials followed by three blocks of 40 pictures each. Each participant received the same picture–distractor combinations for each of the experimental conditions; however, the order of stimuli presentation was randomised. Before each trial a cross appeared on the centre of the computer screen for 500 ms. Participants were instructed to focus on this cross to ensure central fixation. A distractor word would then appear 2 degrees either to the left or right side of the centre of the screen for 200 ms to ensure the distractor word was processed by one visual field only (Bourne, 2006). The distractor word then disappeared and a picture was presented centrally. Participants were required to name the target picture by speaking into the microphone. Once the voice key was triggered for a stimulus, the picture disappeared from the screen and the response time was recorded. Inaccurate
responses included incorrect or incomplete responses. Voice key activation errors (e.g.,
mouth clicks or voicing) were recorded as invalid responses. Naming responses were
transcribed online as well as tape-recorded to determine response accuracy. Time
between trials was self-paced and breaks were taken between each of the three blocks.
Each testing session lasted approximately 45 minutes.

RESULTS

Healthy control group

Linear mixed model analyses were conducted on the dependent variables of accu-
rate and response time with the independent variables of distractor condition (SEM,
PHON, REP, UNR) and visual field (RVF, LVF) and the random factor of partici-
pant. In the analysis of accuracy any responses where a participant produced a voice
key activation error (i.e., mouth clicks or voicing that was recorded as an invalid
response) were excluded. Additionally, response times below 200 ms or above 1200
ms were determined to be extreme values and were also excluded. This resulted in the
exclusion of 87 trials (10.36% of all data) from the analysis of response accuracy. For
the analysis of response times, any items where a participant produced an incorrect
response were also excluded. This resulted in the exclusion of an additional 26 trials
(3.09% of all data) for the analysis of response times. Additionally, as it was deter-
mined that the data did not have a normal distribution, all data were log transformed.
However, raw data are displayed in figures for ease of interpretation.

Linear mixed-model analyses were conducted on the accuracy of responses for each
distractor condition and visual field. In this analysis fewer or more errors relative to
the unrelated condition were interpreted as facilitation or interference respectively, as
it is assumed that the unrelated distractor words did not contain any overlapping or
competing processes with the target word. Thus faster or more accurate performance
compared to the unrelated condition reflects facilitation, whereas poorer performance
reflects interference.

Significant effects were found for visual field, $F(1, 732) = 5.005, p = .026$, where
more errors were made when distractors were presented to the RVF (96% accuracy)
than the LVF (99% accuracy). In a comparison of distractor conditions significant
effects were found for each distractor condition, $F(3, 732) = 7.378, p < .001$. There
was also a significant interaction between condition and visual field presentation,
$F(3, 732) = 10.283, p < .001$. Figure 1a displays the mean percent accuracy for
each condition in either visual field. This interaction was further evaluated by pair-
wise comparison between conditions within each visual field. A modified Bonferroni
adjustment of $\alpha$ levels was used to correct for the possibility of inflated Type I error,
where $p$ values are ranked from smallest to largest and compared to an adjusted $p$ value
based on the number of comparisons and their rank order (Jaccard & Turrisi, 2003).
Using this procedure the smallest value required an adjusted $p$ value $< .017$ to reach
significance, the second $< .025$, and the third $< .05$. However, once a non-significant
difference was found, subsequent comparisons were determined to be non-significant.
Using this modified Bonferroni adjustment, there was a significant facilitation effect
for semantic ($p = .01$), repetition ($p = .008$), and phonological ($p = .045$) distractors
in the LVF compared to the unrelated condition. In the RVF only the semantic dis-
tractors were significantly different from the unrelated condition, demonstrating an
interference effect ($p < .001$).
Figure 1. (a) Percent accuracy and (b) mean response times in milliseconds for each distractor condition (SEM, PHON, REP, UNR) and visual field presentation (LVF/RH, RVF/LH) for control group ($n = 7$). Error bars represent mean standard error for each condition.

Linear mixed-model analyses were conducted on mean response times calculated for each participant ($n = 7$) per condition and visual field. In this analysis faster or slower response times relative to the unrelated condition were interpreted as facilitation and interference respectively. The main effect of condition was significant, $F(3, 705) = 2.713, p = .044$. There was no significant effect of visual field on response times, $F(1, 705) = 2.301, p = .130$. There was also no significant interaction between condition and visual field, $F(3, 705) = 1.268, p = .284$. Subsequent pairwise comparisons were conducted to examine the main effect for condition, using the same modified Bonferroni adjustment of $\alpha$ levels as in the analysis of response accuracy.
These comparisons revealed that the repetition condition showed a significant facilitatory effect compared to the unrelated condition in both visual fields ($p < .001$). Additionally the phonological condition showed a significantly greater interference relative to the unrelated condition in both visual fields ($p = .023$). Figure 1b displays the effect of distractor condition in each visual field on response time.

**Participants with aphasia**

Due to the small sample size, descriptive analyses were conducted on the dependent variables of accuracy and response time with the independent variables of distractor condition (SEM, PHON, REP, UNR) and visual field (RVF, LVF). As for the control group, in terms of response times, faster or slower response times relative to the unrelated condition were interpreted as facilitation and interference effects respectively. Furthermore, in terms of accuracy, fewer or more errors relative to the unrelated condition were interpreted as facilitation and interference effects respectively. Additionally, the Revised Standard Difference Test (RSDT) was used to test whether interference/facilitation effects for each participant with aphasia were significantly different in magnitude to the control group (Crawford, Garthwaite, & Howell, 2009). For the facilitation/interference effects found to be significant in the control group (a significant difference was observed between the unrelated and related conditions), the RSDT statistic was used to test whether the size of this significant effect was of a similar magnitude in the individuals with aphasia. If there was no significant difference in the magnitude of the effect, it was assumed that the individuals with aphasia were showing a significant effect. Such effects were interpreted as intact facilitation/interference mechanisms for these participants. In contrast, facilitation/interference effects for the PWA found to be significantly different in magnitude to the control group are assumed to represent changes in language processing following stroke. However, due to ceiling effects of response accuracy in the control group, this analysis could only be conducted for response times.

*Participant S1.* Any response where a voice key activation error was produced (i.e., mouth clicks or voicing that was recorded as an invalid response) was excluded. Response times below 200 ms or above 2500 ms were considered extreme values and were also excluded. This resulted in the exclusion of 26 trials (21.67% of all data) from the analysis of response accuracy. Additionally, for the analysis of response times, incorrect responses were also excluded. This resulted in the exclusion of an additional 24 trials (20% of all data) for the analysis of response times.

Descriptive analyses were conducted on the accuracy of responses calculated for each condition in each visual field. In the LVF both the repetition condition ($M = 1.00$, $SE = 0.12$) and semantic condition ($M = 0.80$, $SE = 0.11$) showed facilitatory effects relative to the unrelated condition ($M = 0.79$, $SE = 0.12$), whereas the phonological condition ($M = 0.79$, $SE = 0.12$) did not show either facilitation or interference relative to the unrelated condition. In the RVF both the semantic condition ($M = 0.39$, $SE = 0.12$) and phonological condition ($M = 0.62$, $SE = 0.12$) showed interference effects relative to the unrelated condition ($M = 0.69$, $SE = 0.12$), whereas the repetition condition ($M = 0.71$, $SE = 0.12$) showed facilitation relative to the unrelated condition. However, due to ceiling effects in the control group, interference/facilitation in terms of response accuracy could not be compared with...
differences across conditions in the control group. Figure 2a displays the accuracy of responses in each condition for either visual field.

Descriptive analyses were conducted on mean response times calculated for each condition in each visual field. In the LVF the semantic condition ($M = 1035.78$, $SE = 130.78$), phonological condition ($M = 1079.13$, $SE = 138.42$), and repetition condition ($M = 984.00$, $SE = 104.63$) all showed a facilitatory effect relative to the unrelated condition ($M = 1241.80$, $SE = 123.80$). Using the RSDT only the semantic

![Figure 2](image.png)

**Figure 2.** (a) Percent accuracy and (b) mean response times in milliseconds for each distractor condition (SEM, PHON, REP, UNR) in each visual field (LVF/RH, RVF/LH) for S1. Error bars represent mean standard error for each condition.
Figure 3. (a) Percent accuracy and (b) mean response times in milliseconds for each distractor condition (SEM, PHON, REP, UNR) in each visual field (LVF/RH, RVF/LH) for S2. Error bars represent mean standard error for each condition.

condition showed a greater facilitation effect in the LVF compared to the control group ($p = 0.03$). There was no significant difference in the magnitude of the facilitation effect of repetition distractors between controls and S1.

In the RVF only the repetition condition ($M = 934.00, SE = 151.15$) showed a facilitatory effect, whereas the semantic condition ($M = 1220.60, SE = 202.78$) and phonological condition ($M = 1388.29, SE = 171.38$) both showed interference effects relative to the unrelated condition ($M = 1105.75, SE = 160.32$). Using the RSDT only
the phonological condition showed a greater interference effect than the control group \( (p = .05) \). There was no significant difference in the magnitude of the facilitation effect shown for repetition distractors between controls and S1. Figure 2b displays mean response times recorded for each condition in either visual field.

Participants S2. Any response where a voice key activation error was produced (i.e., mouth clicks or voicing that was recorded as an invalid response) was excluded. Response times below 200 ms or above 2500 ms were considered extreme values and were also excluded. This resulted in the exclusion of 11 trials (9.16% of all data) for the analysis of response accuracy. Additionally, for the analysis of response times, incorrect responses were also excluded. This resulted in the exclusion of an additional seven trials (5.83% of all data) for the analysis of response times.

With respect to accuracy, the semantic condition \( (M = 1.00, SE = 0.06) \), phonological condition \( (M = 1.00, SE = 0.06) \), and the repetition condition \( (M = 1.00, SE = 0.06) \) all showed facilitatory effects relative to the unrelated condition \( (M = 0.93, SE = 0.06) \) in the LVF. In the RVF both the semantic condition \( (M = 0.79, SE = 0.06) \) and phonological condition \( (M = 0.80, SE = 0.06) \) showed interference effects relative to the unrelated condition \( (M = 1.00, SE = 0.06) \), whereas the repetition condition \( (M = 1.00, SE = 0.06) \) showed neither facilitation nor interference relative to the unrelated condition. However, due to ceiling effects in the control group, interference/facilitation in terms of response accuracy could not be compared with differences across conditions in the control group. Figure 3a displays the accuracy of responses in each condition for either visual field.

In terms of response times, both the phonological condition \( (M = 1124.17, SE = 87.59) \) and repetition condition \( (M = 1016.07, SE = 76.02) \) showed a facilitatory effect in the LVF relative to the unrelated condition \( (M = 1151.07, SE = 78.80) \), whereas the semantic condition displayed an interference effect \( (M = 1304.36, SE = 84.70) \). Using the RSDT there was no significant difference in the magnitude of the facilitation effect shown for repetition distractors between controls and S2.

In the RVF only the repetition condition \( (M = 1167.80, SE = 105.30) \) showed a facilitatory effect, whereas the semantic condition \( (M = 1324.10, SE = 129.00) \) and phonological condition \( (M = 1268.80, SE = 129.00) \) both showed interference effects relative to the unrelated condition \( (M = 1214.15, SE = 113.10) \). Using the RSDT there was no significant difference in the magnitude of the facilitation effect shown for repetition distractors or the interference effect of phonological distractors between controls and S2. Figure 3b displays mean response times recorded for each condition in either visual field.

**DISCUSSION**

This study investigated whether there is an attentional bias towards stimuli initially presented to the right hemisphere that influences spoken word production in individuals with aphasia. Using a picture–word interference task, a greater overall facilitation effect was found from distractor words presented in the LVF/RH condition for both participants with aphasia. However, this effect varied depending on the type of distractor presented, suggesting that different aspects of spoken word production may be influenced by hemispatial bias. In contrast, the control group showed a more bilateral pattern of results. These results have implications for changes in hemispheric lateralisation and inhibition in healthy ageing, as well as changes in
hemispheric attentional mechanisms influencing spoken word production in aphasia. The results of the control group will be discussed first with respect to healthy ageing effects, followed by a discussion of the results of the two participants with aphasia.

Healthy ageing and lateralised picture–word interference effects

In contrast to the right visual field/left hemisphere (RVF/LH) bias due to left hemisphere language dominance in studies investigating young adults, there was a bilateral pattern of results in the healthy older control group. Such results are consistent with Cabeza’s (2002) model of Hemispheric Asymmetry Reduction in Older adults, or the HAROLD model. This model postulates that cognitive functions that tend to be more lateralised in young adults, including left hemisphere lateralisation of language functions, become less differentiated in the process of healthy ageing. To the authors’ knowledge, no other studies have examined the effect of healthy ageing on lateralised picture–word interference effects. Thus the bilateral pattern of results of the control group can be viewed as being in line with the HAROLD model. According to Cabeza (2002), this decrease in hemispheric asymmetry may result from either a dedifferentiation of specialised functions of each hemisphere, or as a compensatory strategy in response to general cognitive decline.

Although little hemispheric bias was evident for either visual field presentation, differing facilitation/interference effects were evident when analysing the type of distractor. In terms of response times there was an overall facilitation effect for the repetition condition, suggesting that presentation of the target word significantly aids in the retrieval of the word. This is in contrast to the interference effect found in the phonological condition, suggesting that the presentation of distractor words with the same initial sounds actually interferes with word retrieval.

Although previous research suggests that phonologically related distractor words produce a facilitation effect; such effects have been found when distractor words are presented simultaneously with, or immediately following, picture presentation (Ferreira & Pashler, 2002; Melinger & Rahman, 2004; Wilshire et al., 2007). In the current study all distractor stimuli were presented immediately prior to picture presentation. This was necessary in order to examine divided visual field effects, as pictures were presented centrally in order for participants with aphasia to view the stimuli sufficiently for the naming task. Additionally, picture stimuli appeared on the screen until the participant began to respond. Thus, distractor words could not appear simultaneously with or immediately following picture presentation. However, this did not allow for time-course effects to be examined, particularly with respect to different distractor conditions as in previous studies. Despite this limitation, our findings are consistent with Schriefers et al. (1990) who found that phonological distractors produced an interference effect when presented immediately prior to picture presentation, and suggested that at this early stage of word retrieval accessing of conceptual information is occurring, such that the presentation of phonological information may hinder word retrieval.

Another difference to note between the procedures used in the current study and previous research is the modality in which the distractor word was presented. Some studies have used written word distractors, as was used in the current study (Ferreira & Pashler, 2002; Melinga & Rahman, 2004). However, other studies have employed auditory word presentation of distractor words (Schriefers et al., 1990; Wilshire et al.,
Thus discrepancies found between distractor conditions across studies may also relate to the modality of presentation, not only timing of distractor presentation.

In terms of accuracy of responses a semantic interference effect was evident in the RVF/LH condition, which was not found in the analysis of response times. Such semantic interference is consistent with the literature relating to decreased inhibitory functions in healthy ageing, which suggests that although young adults display a negative priming effect, or inhibition, for irrelevant information, this decreases in healthy ageing (Collins & Luftus, 1975; Zacks & Hasher, 1997). Furthermore, with respect to the limited-capacity theory of attention, a decrease in inhibitory function would also place increased demands on the system and in turn contribute to less-accurate word retrieval.

Further condition effects found in relation to response accuracy include the facilitation of repetition, semantic, and phonological distractors presented in the LVF/RH. These facilitation effects were not evident in the RVF/LH condition, showing neither facilitation nor interference. However, due to the high accuracy scores of the healthy older control group, lack of facilitation/interference of naming in the RVF/LH may reflect a ceiling effect for accuracy. Thus conclusions regarding differences between conditions across hemispheres cannot be drawn in terms of response accuracy.

**Lateralised picture–word interference in aphasia**

Several similarities can be seen in the results of the two participants with aphasia. With respect to naming accuracy, both participants named items more accurately following a semantic or repetition distractor word presented in the LVF/RH, relative to the unrelated distractors. In contrast, in the RVF/LH condition only items named following repetition distractors were produced more accurately than items in the unrelated distractor condition. However, due to the high accuracy scores of the healthy older control group, no comparison was able to be made between participants with aphasia and the control group in terms of response accuracy, thus the interpretation of any facilitation/interference effects cannot be explored further.

In terms of naming response times both participants with aphasia named items faster following a phonological or repetition distractor in the LVF/RH condition relative to unrelated distractors, whereas again only items following a repetition distractor were named faster than items in the unrelated condition in the RVF/LH. These facilitation effects were found to be of a similar magnitude to the effects in the control group, and thus may represent intact mechanisms for these two participants with aphasia. Additionally, both participants were slower to name items following the presentation of either a semantic or phonological distractor in the RVF/LH. While these interference effects were of a similar magnitude to controls for S2, S1 showed a significant difference from controls for the phonological distractors, suggesting that the presentation of similar word forms creates enhanced interference effects in the RVF/LH condition for this individual.

Another discrepancy found between the participants with aphasia was the effect of semantic distractors on response times in the LVF/RH condition. While the presentation of semantic distractors resulted in slower response times relative to the unrelated distractors for S2, they produced a facilitation effect for S1 that was significantly greater in magnitude from controls. Such a discrepancy may reflect differences between the type and severity of the participants’ language impairments. For example, S1 showed a significant word retrieval deficit, displaying both semantic and phonological
paraphasias. In contrast, S2’s word finding deficits were mild. Thus semantic facilitation effects for S1 may stem from prolonged processing required for word production, which may have been facilitated by increased semantic activation. Furthermore, for S2, this semantic activation may have created increased competition for word production, resulting in interference effects of a similar magnitude to the control group.

Consistent with this interpretation, Wilshire et al. (2007) found an overall facilitation effect of centrally displayed semantic distractors in a case study of a person with aphasia with semantic deficits. Such facilitation was attributed to prolonged semantic processing, which was aided by the presentation of a semantically related word. This is consistent with the results of the current study, with respect to the semantic facilitation observed for S1 in the LVF/RH condition, which may reflect altered semantic processing. The present findings extend those of Wilshire et al. (2007) to suggest that this effect may primarily reflect right hemisphere mechanisms initially. An alternative explanation relates to differences in recovery stage. Ansaldo, Arguin, and Roch Lecours (2002) found differing results on a lateralised lexical decision task dependent on the time post-onset of aphasia. In the current study the longer time post-onset of S1 relative to S2, may have resulted in a greater facilitatory effect in the right hemisphere condition.

Overall, these results suggest a LVF/RH attentional bias for the processing of linguistic material in people with aphasia, and indicate that presenting stimuli to the damaged LH may hinder word retrieval in some circumstances. This LVF/RH bias is consistent with the literature examining hemispace effects in people with aphasia (Coslett, 1999; Crosson et al., 2005, 2007; Dotson et al., 2008). Such research has found a right hemisphere attentional advantage for linguistic tasks presented in the left hemispace; that is, the side of space corresponding to the left visual field. Although these findings provided the basis of the predictions in the current study, the method of activating hemispheric attentional mechanisms in such studies did not ensure that stimuli presentation was limited to one visual field, and thus processed only by the contralateral hemisphere initially. As such, the present findings extend this work to further demonstrate the advantage of selectively presenting linguistic material to the right hemisphere.

These results indicate that future research examining linguistic tasks in people with aphasia should consider the presence of such facilitation/interference effects on semantic and phonological processing. Such effects may have implications for language rehabilitation following left hemisphere damage in aphasia. For example, a study by Crosson et al. (2005) investigated the effects of people with aphasia turning their head to the left or performing left-hand movements to facilitate right hemisphere attentional and initiation regions respectively during language treatment. This research found improved language performance following treatment in both of these conditions. Furthermore, a study by Dotson et al. (2008) found improved naming following treatment which manipulated spatial attentional mechanisms to target the right hemisphere in people with aphasia. Thus the results of the current study further support the use of such techniques in language rehabilitation, and provide another potential method for enabling this preferential delivery of stimuli.

In the absence of further research into hemispheric differences in people with aphasia, the results can be discussed in relation to the processes expected in healthy control participants. The results of the current study are in almost direct opposition to those found in healthy young adults, with phonological and repetition facilitation effects.
in the LVF/RH condition, and phonological interference in the RVF/LH condition. This difference in right hemisphere facilitation may reflect a reorganisation of hemispheric language processing post-stroke, such that right hemisphere mechanisms that cause interference in healthy individuals are now associated with facilitation. Similarly, disruptions in left hemisphere phonological processing during word retrieval may account for the different pattern of phonological interference, compared to phonological facilitation in controls.

The current study has extended knowledge in the area of hemispheric attentional mechanisms in aphasia. Where previous studies employed methods such as turning the head to examine hemispheric effects (e.g., Crosson et al., 2005; Dotson et al., 2008), the current study used divided visual fields. This approach more selectively presented stimuli to one hemisphere, and allowed for a more systematic examination of hemispheric attentional mechanisms. However, in order to further support the preliminary results of the two participants in the current study, data from a larger cohort of participants with aphasia would be required.

Future research in this area may have implications for language rehabilitation following left hemisphere damage in aphasia. Research by Crosson et al. (2005) and Dotson et al. (2008) has found improvements in language performance following treatment targeting right hemisphere attentional mechanisms and the present study provides additional evidence that presenting words selectively to the left visual field and right hemisphere has the potential to facilitate word retrieval. The identification of new conditions that optimise language performance in aphasia deserves further consideration in terms of possible rehabilitation approaches.

REFERENCES


**APPENDIX**

**Stimuli**

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