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Treatment of word-finding deficits in fluent aphasia through the manipulation of spatial attention: Preliminary findings

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Abstract

Background—Attention, the processing of one source of information to the exclusion of others, is important for most cognitive processes, including language. Evidence suggests not only that dysfunctional attention mechanisms contribute to language deficits after stroke, but also that orienting attention to a patient's ipsilesional hemispace recruits attention mechanisms in the intact hemisphere and improves language functions in some persons with aphasia.

Aims—The aim of the current research was to offer proof of concept for the strategy of improving picture-naming performance in fluent aphasia by moving stimuli into the left hemispace. It was hypothesised that repeated orientation of attention to the ipsilesional hemispace during picture naming would lead to improved naming accuracy for participants with fluent aphasia.

Methods & Procedures—Three participants with stable fluent aphasia received daily treatment sessions that consisted of naming simple line drawings presented 45 degrees to the left of body midline on a computer monitor. Naming probes were administered before initiation of the treatment protocol to establish a baseline, and before each treatment session to measure change during treatment. The C statistic was used to establish the stability of baseline performance and to determine whether the slope of the treatment phases differed significantly from the slope of the baseline.

Outcomes & Results—Two of the three participants showed significant improvement over baseline performance in the percent correct of naming probes. One participant showed no improvement over baseline accuracy.

Conclusions—Results suggest that engaging right-hemisphere attention mechanisms may improve naming accuracy in some people with fluent aphasia. Findings justify further investigation of this treatment in a larger controlled study.

Attention is critical for most cognitive activities, including language, particularly when conscious effort is directed towards the activity. Without the ability to selectively attend to one source of information as opposed to others, we would quickly be overcome by hundreds of stimuli that constantly surround us. Attention deficits co-occur with aphasia and may affect language performance (Erickson, Goldinger, & LaPointe, 1996; Lapointe & Erickson, 1991; McNeil & Doyle, 2000; Murray, Holland, & Beeson, 1997; Shuren, Hammond, Maher, Rothi, & Heilman, 1995). Although spatial attention has been used as a model to study attention processes (Heilman & Valenstein, 2003), the relationship between spatial attention and aphasia has rarely been studied. This may be due to the observation that spatial neglect is most obvious with right-hemisphere lesions (Fuster, 2003; Heilman & Valenstein, 2003). However, a study by Petry, Crosson, Gonzalez Rothi, Bauer, and Schauer (1994) demonstrated spatial attention deficits in the right hemisphere of patients with aphasia resulting from left-hemisphere lesions. Compared to controls, persons with aphasia had unique patterns of responding slower to right- as opposed to left-sided visual cues when attention was first cued to the opposite side of space, or when attention was focused on a central fixation point. Larger discrepancies between the right and left visual fields were correlated with poorer performance on various language measures. Results of this study suggested that spatial attention deficits frequently accompany aphasia and covary with the severity of aphasia.

Subsequently, two other studies demonstrated that simple manipulation of the hemisphere from which stimuli are presented improved language performance. Anderson (1996) described a patient with aphasia following left temporoparietal and right parietal infarcts who had no difficulty cancelling lines or pictures of meaningful objects when the pictures to be cancelled were presented *visually*. However, when pictures to be cancelled were *named* by the experimenter, thus requiring lexical/semantic processing, the patient demonstrated disproportionate difficulty in cancelling pictures in the right, as opposed to the left, hemisphere. Apparently, the right parietal lesion did not damage the critical right-hemisphere spatial attention mechanism, as there were no conditions under which attention in the left hemisphere was impaired. The author concluded that the patient had a form of neglect for lexical/semantic processing in the right side of space. However, the study also demonstrates that the ability to identify pictures on the basis of lexical-semantic input improved when stimuli were presented in the intact left hemisphere, i.e., the hemisphere contralateral to the hemisphere with presumably intact spatial attention mechanisms. This finding suggests that shifting the hemisphere from which stimuli are presented may be a way of overcoming impaired attention mechanisms in aphasia.

A study by Coslett (1999) again showed improved language by use of the intact hemisphere in some brain-damaged individuals and clarified the relationship between spatial attention and language. He demonstrated that in patients with parietal lesions, but not in patients with lesions excluding the parietal lobe, language performance improved when stimuli were presented in the ipsilesional hemisphere (i.e., the hemisphere contralateral to the intact hemisphere). On the basis of this finding, the author concluded that parietal-lobe mechanisms serve to hold stimuli in the contralateral hemisphere in registration with the appropriate processing mechanisms. Thus, like the Anderson (1996) study, Coslett's findings suggest that presenting stimuli from the intact hemisphere provides a means for overcoming impaired attention mechanisms.

The implication for aphasia therapy is that moving stimuli into the left hemispace may improve language performance for some individuals with aphasia. In the aforementioned studies, the patients who responded to this manipulation of sensory input had sustained lesions in posterior regions of the brain, specifically the parietal (Coslett, 1999) or temporoparietal (Anderson, 1996) regions, and the manipulation of sensory input would affect posterior attention mechanisms (Fuster, 2003; Heilman & Valenstein, 2003). Aphasias associated with lesions confined to these regions are generally fluent, indicating that patients with fluent aphasias would be more likely to benefit from such a manipulation than nonfluent patients.

The goal of the current study was to gather preliminary data, using a simple baseline-treatment design, to offer proof of concept for the strategy of improving picture-naming performance in fluent aphasia with a newly developed experimental treatment designed to engage intact right-hemisphere attention mechanisms by moving stimuli 45 degrees to the left of body midline. It was hypothesised that repeated orientation of attention to the ipsilesional hemispace during picture naming would lead to improved naming accuracy for participants with fluent aphasia.

Patients who demonstrated fluent aphasias during the subacute period (between 2 to 4 weeks post onset) were defined as the population of interest for the current study. This criterion was established because the language of many individuals with nonfluent aphasias in the subacute period may become less nonfluent during the process of recovery, and eventually their language output can resemble that of fluent patients. However, such patients commonly have damage to anterior cortical areas (Alexander, 2003), and may not have damage to the parietal substrates that Coslett (1999) indicated were important for spatial attention in aphasia. Thus, patients with nonfluent aphasias in the subacute period, who subsequently demonstrate fluent output, may be less likely to benefit from the treatment. The acute period (0 to 2 weeks post onset) was not used to define fluent language because acute processes such as oedema, which do not permanently damage tissue but render it temporarily nonfunctional, could cause nonfluent symptoms during the acute period that are not related to permanent tissue damage. Language symptoms rather than lesion location were chosen to define the population of interest because lesion within the parietal lobe was not a sufficient condition linking spatial attention to language function, and because existing lesion location data were not specific enough to be useful in selecting patients (Coslett, 1999).

One potential mechanism of action for this treatment is that engagement of attention mechanisms in the intact hemisphere facilitates the transfer of some language activities either to perilesional cortex or to the intact hemisphere. If such a change in neural substrates for language is facilitated, then improvement in naming accuracy should generalise to untreated, in addition to treated, words. A second potential mechanism of action for this treatment is that it facilitates learning of words by engaging intact attention mechanisms during training but does not permanently alter neural substrates for language or attention. If such a mechanism were responsible for treatment effects, then learning should be specific to those words that are trained with little generalisation to untrained stimuli. Finally, if positive results could be obtained in this exploratory study, investment of further resources in a larger, better-controlled treatment study would be justified.

METHOD

Participants

Three participants with fluent aphasia received the experimental attention treatment. Participants had left-hemisphere damage resulting from stroke, as determined by medical records. No patient was treated sooner than 4 months post-stroke, since the most rapid

period of spontaneous recovery should be completed within that time period. Further, to ensure stability of naming performance, the *C* statistic (Tryon, 1982) was used to statistically verify that no significant changes in picture naming performance occurred during pretreatment baseline sessions (see Results section). All participants gave written informed consent in accordance with procedures established by the Health Science Center Institutional Review Board at the University of Florida.

All participants had a substantive anomia as indicated by a raw score of 46 or less on the Boston Naming Test (BNT: Kaplan, Goodglass, & Weintraub, 1983). Participants were classified as having fluent language output 2 to 4 weeks post onset. This time period was used because the language output of fluent and nonfluent patients frequently becomes more similar and more difficult to distinguish as they recover after their strokes. Thus, the subacute symptoms may be a better indicator of the nature of the underlying deficit (see discussion in the introduction section). Classification was determined by a neurologist or speech/language pathologist's description of the patient as having a "fluent" aphasia during this time period, or by a description of the patient's language output in the medical record that was consistent with a diagnosis of a fluent aphasia. For this study, fluent aphasia was defined as: an absence of difficulty initiating spoken output, relatively normal phrase length, and the absence of impaired intonational contour. In the absence of a clear description of language output in the medical record, a speech/language pathologist interviewed a close relative or caretaker about the patient's language output during this period of time, using the above criteria for fluent aphasia. Western Aphasia Battery (WAB: Kertesz, 1982) scores were available for Participants 2 and 3; due to an oversight, they were not available for Participant 1.

Other inclusion criteria were: damage limited to the left hemisphere, English as a native language, and the ability to follow simple verbal directions. Exclusion criteria included the following: right-hemisphere damage; history of drug or alcohol abuse; diffuse injury or brain disease (e.g., Alzheimer's disease, encephalitis, or closed head trauma with more than 6 hours of unconsciousness); and diagnoses of psychotic or major affective disorder, learning disability, developmental language delays, or attention deficit disorder.

Participant 1 was a 44-year-old, left-handed, Caucasian female with 14 years of education. She sustained an ischaemic left middle cerebral artery stroke 27 months before beginning the study. At the time of the study, she was anomic (BNT = 46), and her speech was fluent, with paraphasias and some consistent sound substitutions. Comprehension and repetition were mildly impaired. Due to an oversight, Participant 1 was not administered the WAB.

Participant 2 was a 43-year-old, right-handed, Caucasian female with 12 years of education who sustained a middle cerebral artery infarction 26 months before beginning the study. At the time of the study, she was anomic (BNT = 36) and language output was fluent (WAB Fluency, Grammatical Competence, and Paraphasias score = 9/10). Comprehension was intact (WAB Sequential Commands = 80/80) and repetition was mildly impaired.

Participant 3 was a 70-year-old, right-handed, Caucasian male with 16 years of education. He sustained a middle cerebral artery infarction 4 months before beginning the study. He was severely anomic at the time of the study (BNT = 0). Language output was fluent (WAB Fluency, Grammatical Competence, and Paraphasias = 7/10), and he exhibited moderate impairment in comprehension (WAB Sequential Commands = 41/80). He could not repeat words at all (WAB Repetition = 0/100).

Design

This experiment used a within-participant baseline-treatment (A–B) design. Each participant underwent a period of baseline measurement (the A component of the design), followed by three treatment phases (collectively the B component of the design). This design is appropriate for preliminary investigations, such as the current study, and provides the advantages of: (a) sensitivity to changes during treatment for individual participants once a stable baseline is established, (b) ease of use when limited resources are available, and (c) allowing for examination of individual behavioural data, which provide information about the characteristics of responders and nonresponders that can be used to refine the treatment (Anastas, 1999; McReynolds & Kearns, 1983).

Procedure

Before treatment, each participant received eight or more baseline sessions, during which they performed naming probes to establish baseline accuracy rates. During these baseline sessions, participants were shown 40 black and white line drawings approximately 4 inches by 4 inches in size. The set consisted of 10 pictures from each of the sets used during treatment (different sets were used during phases 1, 2, and 3) and 10 pictures that were not trained during any phase. Depending on initial task performance, participants were shown either low- or balanced-frequency sets of pictures, based on Francis and Kucera's "Frequency Analysis of English Usage: Lexicon and Grammar" (Francis & Kucera, 1982). To determine whether low- or balanced-frequency item sets were used for baseline and training, all participants were given a set of pictures that was balanced for word frequency, which consisted of 12 high-frequency words (21–717 occurrences per million), 12 medium-frequency words (4–20 occurrences per million), and 16 low-frequency words (0–3 occurrences per million). Participants 1 and 2 performed close to ceiling on this set, and therefore were trained on a set of exclusively low-frequency words (0–3 occurrences per million) to prevent them from achieving ceiling effects on the naming tasks.

An internally developed computer program was used for stimulus presentation and recording of accuracy and response times. A computer monitor was situated directly in front of the participant. Pictures were presented in the centre of the monitor. Participants were instructed to name the picture and were informed of a 20-second time limit to respond. The therapist recorded accuracy and response latency by pressing the left (correct response) or right (incorrect response) mouse button. The participant was allowed to provide multiple responses. If the participant was unable to name the picture within 20 seconds, the computer program recorded an incorrect response and automatically advanced to the next item.

Verbal naming probes—To measure progress, participants received naming probes before each treatment session. The naming probes consisted of the same 40 items used during baseline, and the procedure was identical to that used during the baseline sessions.

Attention treatment—The attention treatment comprised three treatment phases consisting of 10 sessions each. During each session, the participant named 50 black and white line drawings, with a unique set used for each phase of treatment. The word frequency distribution of the pictures paralleled that of the sets used in the naming probes and baseline sessions. Each treatment session lasted approximately 45 minutes.

During treatment, a computer monitor was situated 45 degrees to the left of body midline. As described in more detail below, the degree of attentional manipulation during treatment was gradually reduced with each phase in order to reduce the patients' reliance on external manipulations to enhance word finding. The clinician sat slightly to the left and behind the patient during treatment. In order to prevent habituation, Participant 1 sat with body and

head facing ahead and was instructed to turn her head to face the computer monitor when she heard a warning tone. However, because the head turn has an intention component that was not the focus of the experimental treatment manipulation, it was not used for the last two participants. Instead, Participants 2 and 3 were instructed to turn their head and eyes towards the computer monitor for the duration of the treatment session.

Phase 1—The therapist began each trial by pressing a mouse button. For 4 seconds, a warning tone sounded and firework-like stimuli appeared somewhere to the left side of a central fixation point on the computer screen. When the tone and fireworks disappeared, a picture immediately appeared on the upper, lower, or middle portion of the left side of the computer screen. The patient was given 20 seconds to name the stimulus. If the patient did not respond, or named the object incorrectly, then the therapist modelled the correct response and instructed the patient to repeat the word. Modelling was done no more than three times per picture.

Phase 2—The same procedure was used for phase 2, except that the fireworks display was eliminated. Participants were trained on a different set of 50 line drawings from those used in phase 1.

Phase 3—In phase 3, the warning tone was shortened to approximately half a second. After the tone stopped, the computer screen remained blank for approximately 4 seconds before a picture appeared in the centre of the computer screen. Otherwise the procedure was the same as in phases 1 and 2. A unique set of 50 line drawings was used in this phase.

RESULTS

Participants completed verbal naming probes during baseline and before each treatment session. The percentage of correctly named pictures was calculated for each day, and all analyses were performed on these data. The accuracy of trained and untrained items was also calculated.

The C statistic (Tryon, 1982) was used to determine if there was a trend in time series. It is based on the assumption that, in a time series analysis, the variance increases in direct proportion to trends in the mean value of the series; thus, the mean and the variance are both increased when there is a trend. The size of the C statistic reflects the rate at which the difference from the mean changes relative to successive data point changes. The more rapidly the difference from the mean increases relative to successive data point changes, the larger the C statistic (Tryon, 1982).

For each participant, two tests of trends were performed with this statistic. First, to strengthen the ability to make inferences about treatment effects, the percentage of correct responses across daily baseline sessions was statistically analysed to determine the stability of baseline performance. Treatment was not initiated until baseline performance was stable (i.e., there was no significant upward trend for eight sessions). All analyses were performed on the last eight baseline sessions given. Second, the C statistic was used to determine if the slope of the treatment phases differed significantly from the slope of the baseline. Use of the C statistic in this fashion offers the advantage of determining the stability of the baseline, allowing a more confident attribution of subsequent improvements to the experimental treatment.

Participant 1

For participant 1, a stable baseline was obtained for accuracy of the naming probe for the last eight of nine initial baseline sessions ($C=.39$, $Z=1.29$, $p>.05$) and her average percentage

correct at baseline was 64.68 (Figure 1). By phase 3, her average score improved to 99.16% correct. The slope of the total percent correct from the three treatment phases was significantly different from the baseline slope ($C=.93$, $Z=5.81$, $p<.01$). Figure 2 shows improvement in probe items that were trained during the different phases of treatment and on the never-trained probe items. There was some specificity of improvement for the items trained during phases 1 and 2 in that items trained during those phases showed the greatest improvement when they were being trained. However, generalisation of training to other items also occurred, and ceiling was reached on all probe lists during phase 2.

Participant 2

A total of 11 baseline sessions were administered to Participant 2, and a stable baseline was obtained for accuracy of the naming probe for the final 8 sessions ($C=.42$, $Z=1.38$, $p>.05$). Her average percent correct of 64.37 at baseline improved to 84.75% correct during phase 3 (Figure 1). The slope of the total percent of correctly named pictures from the treatment phases was significantly different from the slope of the baseline ($C=.91$, $Z=5.76$, $p<.01$). Again, there was some specificity of effects to probe items trained during phases 1 and 2, with some degree of generalisation to other items (Figure 2).

Participant 3

Participant 3 did not show any improvement during treatment. Although a stable baseline was obtained for the last eight of nine initial baseline sessions ($C=.00$, $Z=.00$, $p<.05$), this was due to the fact that he stayed at 0% correct for all baseline sessions except two, when his percent correct was 2.5% (Figure 1). Because performance on probe items was at 0% on nearly every session, there was no need to separate response to probe items into the items trained during the different phases and never-trained items. Treatment was interrupted for 7 weeks during phase 2 due to patient illness. The slope of the total percent of correctly named pictures from the treatment was not significantly different from the slope of the baseline ($C=-.05$, $Z=-.35$, $p>.05$). Participant 3 named one picture correctly during two baseline sessions, but he remained at 0% for all of treatment.

DISCUSSION

The purpose of this study was to gather preliminary data on the effects of a newly developed experimental treatment designed to engage intact right-hemisphere attention mechanisms to facilitate naming in patients with fluent aphasia. Two of three participants demonstrated a significant improvement in their naming accuracy, as measured by daily probes administered during baseline and treatment. One patient showed no improvement over baseline accuracy. These findings are consistent with previous research indicating that activation of right-hemisphere attention mechanisms after left-hemisphere stroke facilitates naming in some patients (Anderson, 1996; Coslett, 1999). The participant who showed no improvement during treatment exhibited greater impairments in confrontation naming compared to the other participants prior to beginning the study, which suggests that the experimental treatment may be less efficacious for patients with more severe language impairments. However, it should also be noted that the participant's illness might also have impacted the efficacy of treatment. In addition, it is possible that the site of the lesion differed for this participant compared to those who responded to treatment, and that differences in treatment efficacy were related to underlying neural damage. As neuroimaging data were not available for all participants, this hypothesis cannot be evaluated in the current study. Another factor that may have contributed to the success of treatment was that Participants 1 and 2 maintained a significant ability to repeat words, whereas Participant 3 was totally unable to do so. Word repetition was used to correct inaccurate responses during treatment.

Data from probe items trained during the different phases indicated that Participants 1 and 2 showed some specificity of improvement to items trained during phases 1 and 2. However, there also was some degree of generalisation to untrained items, especially for Participant 1. Both Participants 1 and 2 approached ceiling on all probe items by the end of phase 2. These findings suggest that either the neural mechanisms of attention that underlie word finding or the neural mechanisms for word finding themselves change as a result of treatment, benefiting performance on untrained as well as trained items.

The primary goal of this exploratory study was to determine if there was a reason to believe that the treatment was efficacious, and therefore warranted more extensive investigations. The simple A-B design allowed us to determine quickly, and with limited resources, that the treatment has the potential to improve naming accuracy in some patients with fluent aphasia. Given the statistical evidence that naming accuracy during baseline was stable and improvements followed the onset of treatment, the experimental intervention was likely the cause of the observed changes. However, the A-B design makes it difficult to determine the active component that leads to improvement in naming accuracy. The A-B design is more limited regarding the strength of inferences than an A-B-A design or a design in which the experimental treatment is compared with a control treatment that differs only in the presence or absence of the proposed active component of treatment. The A-B design was used rather than an A-B-A design because it was anticipated that the treatment would not be reversible in many cases. The comparison of the experimental treatment to baseline rather than a control treatment limits the ability to isolate the active component of treatment; however, the A-B design sufficiently serves the goal in this study of determining if the treatment is efficacious and warrants further research. Additional investigations are needed to demonstrate that the active component of treatment is presenting stimuli 45 degrees to the left of the patient's body midline.

The goal of demonstrating that the attentional manipulation is the active component of treatment can be accomplished by comparing the attention treatment to a similar control treatment without the attention component. In a previous study in our laboratory (Richards, Moore, Singletary, Rothi, Clayton, & Crosson, 2002), such a design was used to investigate an intention treatment hypothesised to improve naming in nonfluent aphasia. In this study, patients with nonfluent aphasia demonstrated greater improvement during an intention treatment than during the attention treatment used in the current study. This dissociation suggests that the intention manipulation was an active component of treatment. Further, preliminary functional magnetic resonance imaging (fMRI) data collected before and after the intention treatment generally confirmed the importance of the intact hemisphere in language production, although it also was apparent that individual differences in response to treatment existed (Crosson et al., 2005). Performing similar studies for the attention treatment that was the focus of the current investigation will help to verify the underlying mechanisms of treatment. In particular, future studies exploring correlations between treatment outcome and lesion data will be useful in identifying potential neural correlates of the attention treatment. Finally, future studies should address ecological validity. Eventually, strategies to facilitate generalisation of the treatment to functional communication activities should be developed to maximise the impact of the treatment to daily activities.

In summary, results from this preliminary study suggested that shifting attention mechanisms to the intact hemisphere is useful in rehabilitation for some patients with fluent aphasia. Additional research is needed to determine the active component, the underlying neural mechanisms, and the ecological validity of the treatment.

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Figure 1. Naming probe accuracy. The first 8 sessions were baseline sessions, followed by 10 phase 1 treatment sessions, 10 phase 2 treatment sessions, and 10 phase 3 treatment sessions.

Figure 2.

Participants 1 and 2 accuracy by treatment phase. For probe stimulus sets, 10 items were selected from the 50 items trained in each of the three treatment phases. An additional 10 items were never trained. The graph represents the participant's average accuracy in naming probes from each treatment set during baseline and each of the three treatment phases.