The effect of frequency of augmented input on the auditory comprehension of narratives for persons with Wernicke's aphasia

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Abstract

Background: Augmented input refers to the support of any form of linguistic or visual strategy to enhance understanding of language. Previous research for persons with aphasia predominantly focused on the various types of augmented input that can be used to support comprehension.

Aims: The purpose of this study was to determine and compare the effect of varying amounts of augmented input on the accuracy of auditory comprehension for persons with Wernicke's aphasia

Method & Procedures: A within-subject design was conducted with nine participants with Wernicke's aphasia. Based on previous studies done by the authors, the participants reviewed a relevant high-content image, listened to three narratives in three conditions, namely 0%, 50% and 100% augmented input with active partner pointing (AI-PP), and then responded to comprehension items based on the narratives.

Outcomes & Results: Of the nine participants, four gave more accurate responses to comprehension items in the 50% AI-PP condition, three gave more accurate responses in the 100% AI-PP condition, and two participants scored the same in either the 50% and 100%, or in the 0% and 50% conditions. Furthermore, participants did significantly better in the 50% than in the 0% augmented input condition when answering inferential rather than factual questions.

Conclusion: The main clinical implication is that supporting narrative auditory comprehension with augmented input, used as pre-task and during-task stimulation, seems to improve the auditory comprehension of narratives for some persons with Wernicke's aphasia. Moreover, providing augmented input for narratives seems to have a significant effect on the auditory comprehension of inferential questions for some persons with Wernicke's aphasia. Continued research is necessary to determine what types and frequency of augmented input will enhance auditory comprehension for persons with aphasia, specifically Wernicke's aphasia.

Keywords: alternative and augmentative communication; augmented input; comprehension; stroke; Wernicke's aphasia

Wernicke's aphasia typically results from damage to the left posterior temporoparietal cortex after a cerebral vascular accident (CVA). Wernicke's aphasia is characterised by impaired repetition and fluent but semantically empty speech, marked by paraphasias and neologisms (Goodglass et al., 2001). In addition, phonological analysis abilities are affected, impairing auditory comprehension to the extent that Wernicke's aphasia is often thought of as a "quintessential" comprehension disorder (Robson et al., 2013, 2014; Thompson et al., 2015).

Despite these core impairments, research has shown that other linguistic skills, such as reading keywords, may be relatively preserved (Robson et al., 2012; Thompson et al., 2015). The capacity of persons with Wernicke's aphasia to understand visual modalities such as photographs and images is also seemingly less impaired than their auditory modalities (Robson et al., 2012; Thompson et al., 2015). People with Wernicke's aphasia may therefore benefit from the use of linguistic or visual strategies to support their comprehension.

When visual and linguistic strategies are employed by the communication partner to enhance the comprehension of the person with aphasia (PWA), it is called augmented input (Dada et al., 2019; Garrett & Richman, 2007; Wallace et al., 2012). An example of augmented input is when the communication partner points to a matching keyword and picture while simultaneously saying the word to the PWA. The information is therefore provided using multiple modalities, increasing the ability of the PWA to comprehend the spoken words.

Within the resource allocation theory, augmented input can be explained as the use of strategies to successfully extract information by allocating resources to unfamiliar listening tasks (Petroi et al., 2014; Wallace et al., 2012, 2018). The terms attention, processing resources, capacity, and cognitive effort are used interchangeably within the resource allocation theory to refer to a pool of resources, where the allocation to one task may result in decreased performance for another task if they are contending for the same restricted capacity resources (McNeil et al., 2004; Slansky & McNeil, 1997). Augmented input strategies may therefore support comprehension through highlighting prominent information provided by the communication partners, which reduces the cognitive load and amplifies former knowledge (Wallace et al., 2012; Wood et al., 1998).

The Written-choice Communication Strategy is a prime example of using a combination of linguistic and visual modalities to strengthen comprehension to eventually support expression (Garrett & Beukelman, 1995; Lasker, Hux et al., 1997). This strategy is a conversational technique where communication partners provide written word choices to the PWA and then allow them to choose appropriate responses from a written array. The Written-choice Communication Strategy is supported by the work of Garrett, Lasker, and Smith (2007) who specifically found that using text facilitated communication for PWAs. These results held true for three of their participants with severe to profound aphasia, of which one was a person with Wernicke's aphasia.

Several studies that investigated the effect of augmented input on the reading comprehension of the PWA delivered varied results. Brennan et al. (2005), Rose et al. (2011), and Wilson and Read (2016) found no significant improvement in comprehension when pairing visual supports with reading materials for the PWA. In contrast, Dietz et al. (2009, 2014) established the benefits of photographs in supporting reading comprehension in some PWAs. The differences in the results of these studies may be attributed to the difference in visual materials (line drawings versus photographs), in how they tested reading comprehension (sentence completion versus comprehension questions), and in the participant characteristics. For example, Dietz et al. (2009, 2014) studied participants with Broca's aphasia only, while the participants in the study by Rose et al. (although more diverse in diagnosis) demonstrated substantially higher scores in terms of language and reading impairments on the same standardised measures as used by Dietz and colleagues.

When investigating the use of augmented input for auditory comprehension, Wallace et al. (2012) examined the use of visual support and found that it did not influence participants' response accuracy for sentence completion tasks. A total of 21 PWAs listened to four stories, one in each of the four conditions (no-context photographs; low-context drawings with embedded no-context photographs; high-context photographs; no visuographic support). Auditory comprehension was then measured by assessing participants' accuracy in responding to 15 multiple-choice sentence completion statements related to each story. Results showed no significant differences in response accuracy across the four conditions. Three of the 21 participants had Wernicke's aphasia. As expected, the persons with Wernicke's aphasia achieved lower accuracy scores compared to the participants with mild aphasia. Specifically, the three participants with Wernicke's aphasia achieved the lowest accuracy scores in the no-context photographs -, the high-context photographs -, and no visuographic support conditions. The lowest score in the low-context drawings with embedded no-context photographs condition was also achieved by a participant with Wernicke's aphasia, and the other 2 participants still scored below the average accuracy. The authors noted, however, that adding pre-task stimulation as well as combining text and visuographic images as augmented input could result in greater benefits derived from image supports. Dietz et al. (2014) supported this idea as their study showed that pre-task stimulation is deemed beneficial for comprehension, while Wallace et al. (2018) supported the idea of combining modalities for improved comprehension.

Dada et al. (2019) conducted a similar study with 12 participants with chronic aphasia, the majority of whom were persons with Broca's aphasia. The researchers looked at referencing text to match auditory input with visual input. They referred to this process as augmented input with partner pointing (AI-PP). The participants listened to two narratives – one condition with AI-PP (the researchers pointing to relevant Picture Communication Symbols (PCS) as the narrative was being read) and one with no AI-PP (no active partner pointing to PCS). Auditory comprehension was then measured by assessing participants' accuracy in responding to 15 multiple-choice closed-type statements with four response options related to the narratives. The researchers included pre-task stimulation and frequency of AI-PP in their research. It was found that partner-referenced no-context PCS images, combined with high-context visual support as a form of augmented input, seemed to improve the auditory comprehension of narratives for some persons with chronic aphasia. However, there were no persons with Wernicke's aphasia represented in their study.

Brown et al. (2018) examined the use of written information only, auditory information only, and a combination of written and auditory information to support the comprehension of simple active sentences by the PWA. Two of the 27 participants presented with Wernicke's aphasia – one moderately affected and the other severe. Most participants demonstrated better performance in the combined modality condition by means of average accuracy scores. Wallace et al. (2018) also found that, depending on the length of the narrative, presenting multi-sentence narratives through more than one modality may support comprehension for some PWAs. Interestingly, Brown et al. (2018) found that persons with severe aphasia delivered significantly more accurate performances during the combined modality condition than during the written only condition, whereas persons with mild to moderate aphasia showed only a slight accuracy difference across conditions. Admittedly, the study by Brown et al. (2018) focused on sentence and not narrative comprehension. Wallace et al. (2018), on the other hand, had participants representing a wide spectrum of aphasia types and severities, and they could therefore not analyse the data according to aphasia profiles. Nevertheless, the results potentially indicate that varying aphasia types and severities may benefit from multiple modalities in support of comprehension.

In summary, the use of augmented input during comprehension tasks may reduce PWAs' dependence on an impaired auditory system, thereby supporting them to better comprehend information (Brown & Thiessen, 2018; Wallace et al., 2012). The variable outcomes across research studies emphasise the need to systematically evaluate the auditory comprehension benefits that PWAs, especially persons with Wernicke's aphasia, may gain from different frequencies and varying magnitude of augmented input. Previous research predominantly focused on the various types of augmented input strategies that can be used, especially to support reading comprehension. Only one study investigated the frequency of partner pointing needed to support auditory comprehension of PWAs, and no persons with Wernicke's aphasia were included (Dada et al., 2019). Therefore, the purpose of this study was to determine and compare the effect of varying amounts of AI-PP on the accuracy of auditory comprehension for persons with Wernicke's aphasia. In line with previous research findings, this study utilised pre-stimulation as well as multiple modalities (visual and linguistic) as support for auditory comprehension.

Method

Participants

Approval for the study was obtained from the Research Ethics Committee at a university and permission was obtained from the two provincial Departments of Health. Written permission was then obtained from governmental hospitals and clinics, private speech therapy practices, and non-governmental organisations. Nine participants were recruited using three different methods, namely (a) contacting governmental hospitals and clinics; (b) contacting private speech therapists; and (c) contacting non-governmental organisations offering stroke support groups or post-stroke care. Informed consent was obtained from the PWAs via information that had been written according to aphasia-friendly principles and included visual aids to enhance understanding. Each caregiver was asked to assist the PWA and verify that informed consent was provided without any coercion (Dada et al., 2019). After consent had been obtained from 21 PWAs and their caregivers, a screening session was arranged to determine if they met the pre-determined selection criteria.

The selection criteria were as follows: (a) aphasia secondary to a left cerebral vascular accident (CVA); (b) determination of Wernicke's aphasia subtype as determined by the Western Aphasia Battery – Revised (WAB-R) (Kertesz, 2006); (c) minimum of six months post-CVA; (d) English language proficiency; (e) no history of language or cognitive impairment prior to CVA; (f) availability of a significant other (family member or friend) to attend sessions; (g) normal or corrected vision and hearing; and (g) the ability to answer questions of the Written-choice Communication Strategy Screening Test (Garrett & Beukelman, 1995) with 75% accuracy. Furthermore, participants were required to examine ten names on a page and cross out a certain name each time they identified it in a visual perceptual screening test similar to the one used in the studies by Wallace et al. (2012) and Dada et al. (2019). Of the 21, only nine participants eventually met the selection criteria, and they are described in Table 1.

Of note, we purposefully included only people who were identified as having Wernicke's aphasia via the WAB-R AQ and were careful to note that they also demonstrated communication characteristics consistent with a diagnosis of Wernicke's aphasia which supported a clinical diagnosis. In terms of spoken output, we collected some information about participants' performance. Specifically, participants 1, 5, 7, and 9 had frequent paraphasic errors. For example, Participant 1 said, "little baby mion" where "mion" was a phonemic paraphasic error for the concept "lion". Participant 5 said, "sight snow" instead of "white snow", Participant 7 said "reading sook" for "reading book", and Participant 9 said "toot, too, and you?" for "good, good, and you?". These characteristics differed slightly from the remaining five participants whose speech output often had jargon and multiple paraphasic errors within a single sentence. For example, Participant 2 said, "All gone around town and hands to hands", Participant 3 said "There, stealing yes, I want to steal, yes, no …" and Participant 4 finished a closed ended prompt with "Cats! So many cats, wonderful. Where are the budgies now?". Partipant 6 spoke about a dog which wasn't in the target picture she was descriping and in relation to a researcher's questions about the location of the interview, Partiicipant 8 said, "In and out. Everyday. On no. All away. Yes, come back again tomorrow".

Table 1. Participant descriptions

Participant number	Age (in years)	Gender	Educational level	First language	Additional language proficiency	Time post-CVA (in months)	WAB-R auditory comprehension score	WAB-R aphasia quotient (AQ)	WAB-R AQ severity rating
1	69	F	Diploma	Afrikaans	English	84	6.9	81.2	Mild
2	71	M	Postgraduate Degree	Afrikaans	English	9	6.4	63.4	Moderate
3	76	M	Degree	Afrikaans	English	113	5.8	58.2	Moderate
4	84	M	Matric	English	Afrikaans	13	5.8	70.8	Moderate
5	78	F	Degree	English	Afrikaans	72	5.4	27	Severe
6	72	M	Diploma	Afrikaans	English	37	6.85	72.1	Moderate
7	71	F	Matric	Afrikaans	English	16	6.75	71.7	Moderate
8	69	F	Degree	English	Afrikaans	6	6,15	72,9	Moderate
9	60	M	Diploma	isiXhosa	English	7	6,6	52,8	Moderate

Research design

An experimental within-subject design was used to determine the effect of either 0%, 50%, or 100% content unit frequency of AI-PP on the auditory comprehension of narratives. This design permits each participant to be exposed to every condition in the experiment (Charness et al., 2012). The assignment of narratives to the different conditions and the order of condition presentation across participants were systematically varied to reduce the possibility of order and carryover effects (Dada et al., 2019; Wallace et al., 2012).

Materials

Narratives

Three narratives used in the Wallace et al. (2012) study were again used in this study. Each narrative contained five active voice sentences and two main characters (Wallace et al., 2012). Each story covered a problem and a solution. To ensure equivalency the narratives were balanced for (a) number of words (75), (b) mean words per sentence (range: 13-15), (c) mean characters per word (range: 3.77–4.17), and (d) Flesch-Kincaid Grade Level (range: 5.2–5.5). Narratives 2 and 3 had already been adapted to be culturally more appropriate (Dada et al., 2019), and therefore minor changes were also made to the vocabulary of Narrative 1 to also adapt it to the South African context. For example, the word "gas" was replaced with the word "petrol" to ensure the participants' familiarity with the vocabulary, as determined by an expert panel review.The researcher and three postgraduate speech therapists individually read each narrative and developed a list of content units or "words/phrases with meaning" which consisted mainly of nouns, verbs, and adjectives (Dada et al., 2019). Of the 75 words in each narrative, 37 units (single words or phrases) from Narrative 2 and 37 units from Narrative 3 were identified as content units. As Narrative 1 was used as the 0% condition, no content units needed to be identified. These content units were used to develop the augmented input images. Below is a sample of the narratives used in the study:

Narrative 2: Out of petrol (50% condition)

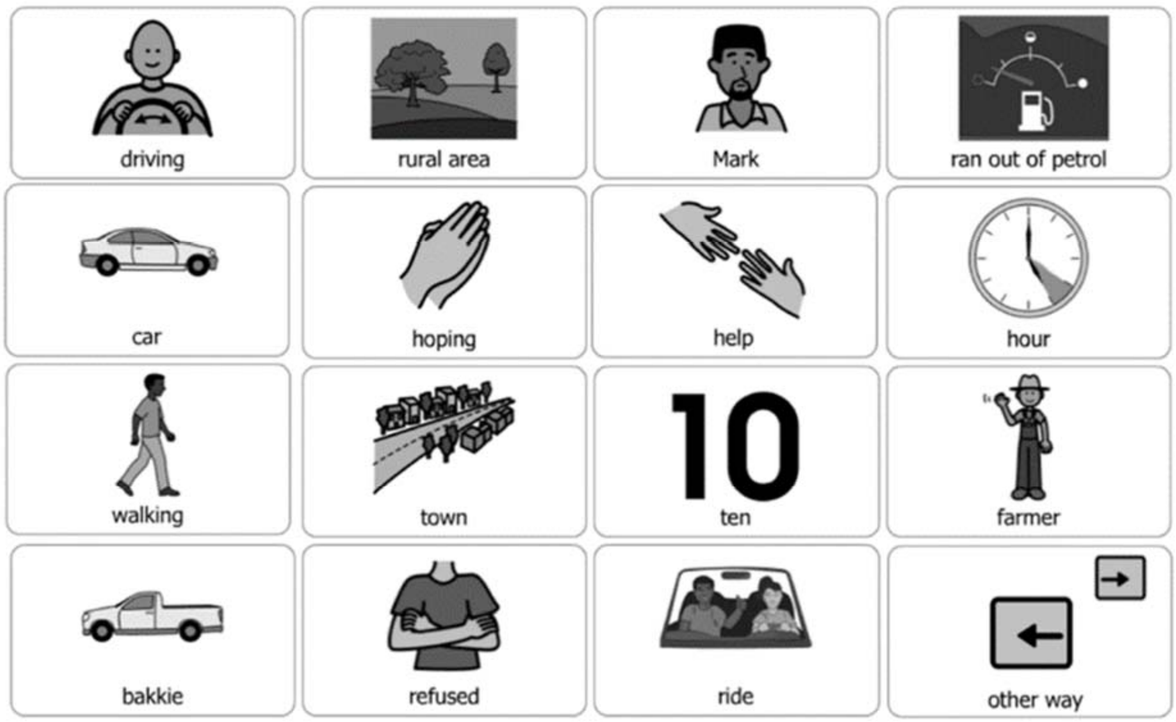
While driving in a rural area, Mark ran out of petrol. He waited in his car, hoping someone would come by to help. After an hour, he gave up and started walking to the nearest town ten kilometres away. Just then, a farmer drove by in a bakkie but refused to give Mark a ride, because he was going the other way. He scolded Mark for not planning ahead when driving in a rural area.

Picture Communication Symbols™ (PCS) images

No-context PCS images were used to supplement the narratives as AI-PP. Worldwide, PCS is the most commonly used aided graphic symbol set (Beukelman & Mirenda, 2013); it is also accessible and widely used in South Africa (Dada et al., 2019).

Narrative 1, *Lost Dog*, was the 0% condition and therefore had no PCS supplementation. Narrative 2, *Out of Petrol*, was supplemented with PCS images at a frequency of 50% of the content units, in other words, altogether 19 PCS images. Narrative 3, *Lost Purse*, was supplemented with PCS images at a frequency of 100% of the content units in other words altogether 37 images. The content units were then used as linguistic keyword support under each PCS image. Sixteen (16) colour images appeared on a page and each one measured 4 cm x 2,5 cm. Some images were used more than once within a single story. Figure 1 shows an example of the PCS images used to supplement the narratives.

Figure 1. Example of no-context PCS images.



High-context photographs

Three high-context photographs from the Wallace et al. (2012) study were used as pre-task stimulation before the researcher read the narrative to the participant. These photographs were associated with each narrative and of a non-personalised nature. The 11 cm x 15 cm photographs were in colour and appeared on a laminated sheet of paper.

Comprehension items

Fifteen (15) closed-type statements and four response options associated with each narrative (e.g., Mark was driving in the (a) rural area; (b) snow; (c) city; or (d) rain) were used to assess participants' comprehension of the narrative using the Written-choice Communication Strategy (Garrett & Beukelman, 1995). The Written Choice Communication Strategy has been shown to facilitate responses from people with all types and severities of aphasia (Garrett & Beukelman, 1995). Of the 15 comprehension items, ten were considered factual questions and five were considered inferential questions. The ten factual questions from each narrative consisted of questions where the required responses alluded to facts that were stated in the associated narrative. For the five inferential questions from each narrative, the required responses were not stated in the narratives but had to be deduced from the given information. Participants would point to the answer they believed to be correct, and the researcher would circle the answer designated by the participant. These items were also used in the study by Wallace et al. (2012). A passage dependency index was calculated for each narrative and associated comprehension items to guarantee that the comprehension items indeed measured comprehension related to the associated narrative (Wallace et al., 2012).

Procedures

The researcher individually met those persons with Wernicke's aphasia (the participants) who had given their consent to participate in the research study, in their homes. For pre-task stimulation, which is the augmented input employed before the experimental task, the participants were shown a high-context photograph and the no-context PCS images as it was deemed beneficial for comprehension by previous research (Dietz et al., 2014; Wallace et al., 2012, 2018). Participants were informed that the images provided some information regarding the narrative that would follow. The pre-task stimulation lasted one minute (Dada et al., 2019), and then a narrative was read to each participant twice at a similar rate (a practiced paced reading of 30 seconds to read each narrative through once). Both the high- and no-context PCS images remained in front of the participant during the reading of the narrative as during-task stimulation in all three conditions. During the 100% AI-PP condition, the researcher simultaneously read the narrative and pointed to the corresponding no-context PCS images, which represented 100% of the content units in each narrative. During the 50% AI-PP condition, the researcher simultaneously read the narrative and pointed to the corresponding no-context PCS images, which represented 50% of the content units in each narrative. During the 0% AI-PP condition, the researcher read the narrative without showing or pointing to any corresponding no-context PCS images. The researcher removed the high-context images in all three conditions, but left the PCS images to be present during the reading out of the comprehension items and response options.

The comprehension items were introduced after the reading of the narrative. Each comprehension item was read aloud twice by the researcher, who simultaneously pointed to each of the response options. The participant then specified their response by either pointing to the desired written option or corresponding PCS image, or (verbally) saying it aloud. The participants were given two minutes to respond to each question (Dietz et al., 2009). The participant then specified their response by either pointing to the desired written option or corresponding PCS image, or (verbally) saying it aloud. The participants were given two minutes to respond to each question based on previous research and to allow for slightly delayed responses as is common for people with aphasia (Dietz et al., 2009). Feedback was provided according to the procedural script to help reassure and motivate the participants at regular intervals. Before moving on to the next item, the researcher repeated the participant's choice, and circled it. The comprehension items and no-context PCS images were removed from the table after all 15 of the comprehension items related to Narrative 1 had been completed, and the participants were offered another comfort break of ten minutes before Narrative 2 commenced. Identical procedures to those outlined above were followed during the reading of the second and third narrative, except that the condition (0%, 50% or 100% AI-PP) and the narrative (1, 2 and 3) were altered for each participant.

Procedural Integrity and Data Collection Reliability

To decrease the risk of inconsistencies in procedures across participants, the researcher followed a procedural script when conducting the experimental task (Schlosser, 2002). An inter-rater viewed a randomly selected 40% of the video recordings of the experimental task to assess procedural integrity in the three conditions using the procedural script. Procedural integrity as a percentage (McMillan & Schumacher, 2010) was calculated by dividing the number of correct steps by the total number of steps (108) and multiplying by 100. Procedural integrity was 47/47 for the researcher pointing to key images at the appropriate time; 3/3 for the researcher removing the visuographic stimuli at the appropriate time; 45/45 for the researcher following the outlined Written-choice Strategy procedures; and 9/13 for the researcher providing consistent feedback throughout the task. Procedural integrity was therefore calculated at 96.3% (indicating good procedural consistency) (McMillan & Schumacher, 2010). Experimenter effects were reduced, as a single trained examiner, the second author, presented the narratives and questions to the participants. This decreased the risk that factors such as rate and intonation would have an effect on the narrative comprehension (Wallace et al., 2012). A research assistant was asked to independently record and compare a randomly selected 30% of the raw data on a Microsoft Excel© spreadsheet, resulting in 100% agreement.

Data Analysis

In addition to descriptive data analysis, we conducted a Friedman non-parametric test for related samples to assess if there were difference among the mean ranks across the three AI-PP conditions (Daniel, 1990). We chose to use non-parametric test because our data did not meet the sphericity assumption for repeated-measures ANOVA and the data set (n=9) was too small to provide sufficient power to detect significant differences using parametric tests. Further, a standard regression analysis was conducted to determine whether WAB-R AQ scores predicted performance on the three experimental conditions.

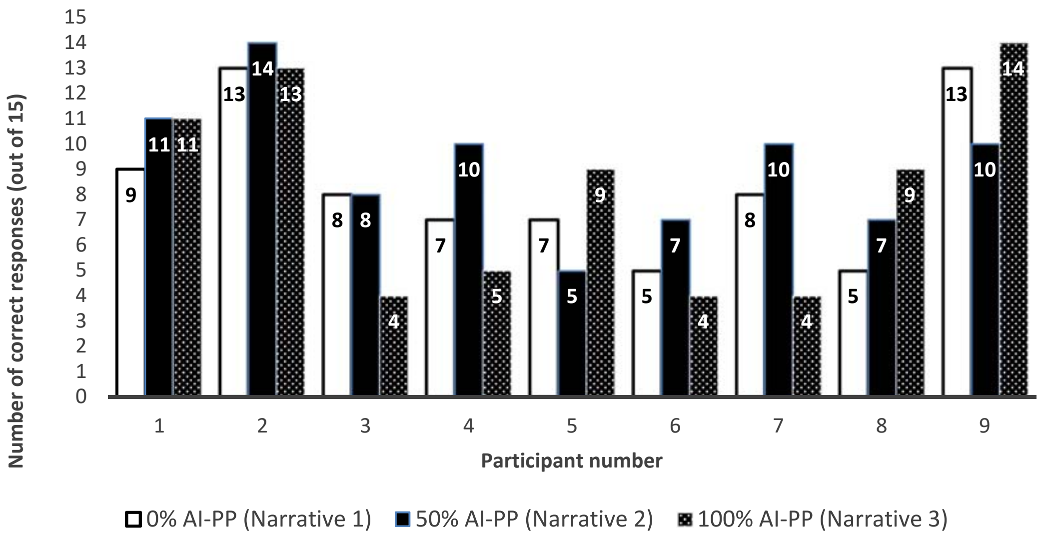
Results

The data were analysed for the dependent measure:relative accuracy of responses for the 0%, 50% and 100% AI-PP conditions . Additionally, individual analysis of participants' response accuracy for factual versus inferential questions is presented.

Comparison Across the Three AI-PP Conditions

Participants received an average accuracy score of 56.79% across the three conditions (M = 8.52 responses; SD = 3.12). A total of four participants (Participants 2, 4, 6, and 7) scored higher in the 50% AI-PP condition than in the other two conditions. Three participants (Participants 5, 8, and 9) scored higher in the 100% AI-PP condition than in the other two conditions, while one participant (Participant 1) received the same scores in the 50% and 100% conditions, and one participant received the same scores in the 0% and 50% conditions (Participant 3). Figure 2 illustrates the individual participation performance across the three conditions.

Figure 2. Individual participant performance across the three conditions



A Friedman non-parametric test for related samples was conducted to assess if there were difference among the mean ranks across the three AI-PP conditions. Results indicated absence of statistically significant difference across 0%, 50%, and 100% AI-PP conditions, χ^2 (2, N=9) = 1.697, P >.005). Additionally, on a post-hoc basis, a non-parameteric Spearman's rho correlation analysis was conducted to find out whether there were significant correlations between WAB-R AQ scores and performance on each of the three experimental conditions. Results indicated no significant correlations between AQ scores and 0% condition (r = -.305, P >.05), 50% condition (r = -.196, P >.05), and (r = -.179, P >.05). Further AQ scores were entered as a predictor variable in a standard regression analysis to predict accuracy of responses for the 0%, 50%, and 100% AI-PP conditions. The prediction model was statistically non significant, F(1,8,) = .182, p >.05, indicating that AQ scores did not predict performance on each of the three experimental conditions. Specifically, AQ scores did not predict accuracy for the 0% condition (Beta = .159, p >.05), for the 50 % condition (Beta=-..452, p > .05), and for the 100% condition (Beta=-.206, p > .05).

Accuracy of Responses during the 0%, 50% and 100% AI-PP Conditions

Participants obtained an average accuracy score of 55.56% in the 0% AI-PP condition, 60.74% in the 50% AI-PP condition, and 54.07% in the 100% AI-PP condition. The accuracy scores ranged from 5–13 out of 15 (M = 8.33 and SD = 2.96) during the 0% AI-PP condition, from 5–14 (M = 9.11 and SD = 2.67) during the 50% AI-PP condition, and from 4–14 (M = 8.11 and SD = 4.01) during the 100% AI-PP condition.

During the 0% AI-PP condition, Participants 3, 4, 5, 6, 7 and 8 (n = 6) obtained accuracy scores below the mean, while participants 1, 2 and 9 (n = 3) had accuracy scores above the mean. The six participants who scored below the mean during the 0% AI-PP condition had an Aphasia Quotient (AQ) severity rating of moderate aphasia, except for Participant 5 whose rating was severe. The three participants who scored above the mean during the 0% condition had an AQ severity rating of moderate, except for Participant 1 whose rating was mild. Participants 2 and 9 had the highest accuracy score during the 0% AI-PP condition, while Participants 6 and 8 had the lowest accuracy score. All these participants had an AQ severity rating of moderate, with Participants 2 and 9 having lower auditory comprehension scores than Participants 6 and 8 on the WAB-R subtest (Kertesz, 2006).

Participants 3, 5, 6, and 8 (n = 4) had accuracy scores below the mean during the 50% AI-PP condition, while Participants 1, 2, 4, 7, and 9 (n = 5) had accuracy scores above the mean. The four participants who scored below the mean during the 50% AI-PP condition had an AQ severity rating of moderate aphasia, except for Participant 5 whose rating was severe. The five participants who scored above the mean during the 50% AI-PP condition had an AQ severity rating of moderate, except for Participant 1 whose rating was mild. Participant 2 had the highest accuracy score during the 50% AI-

PP condition, while Participant 5 had the lowest accuracy score. Participant 2 had an AQ severity rating of moderate and Participant 5's rating was severe (Kertesz, 2006).

Participants 3, 4, 6, and 7 (n = 4) had accuracy scores below the mean during the 100% AI-PP condition, while participants 1, 2, 5, 8, and 9 (n = 5) had accuracy scores above the mean. The four participants who scored below the mean during the 100% AI-PP condition had an AQ severity rating of moderate aphasia, while participants who scored above the mean ranged from severe to mild aphasia (one with severe, three with moderate, and one with mild). Participant 9 had the highest accuracy score during the 100% AI-PP condition; while participants 3, 6, and 7 (n=3) obtained the lowest accuracy score. All four of these participants had an AQ severity rating of moderate; however, Participant 6 had the highest auditory verbal comprehension score on the subtest of WAB-R, followed closely by Participant 7, then Participant 9, and last Participant 3 with the lowest score (Kertesz, 2006).

Individual comprehension items

A Friedman test was also used to analyze whether the mean ranks on the factual and inferential questions differed across the three AI-PP conditions. Results indicated absence of statistically significant difference across 0%, 50%, and 100% AI-PP conditions for factual questions, χ^2 (2, N=9) = .941, P >.005, and for inferential questions χ^2 (2, N=9) = .45, P >.005.

Participants received an average accuracy score of 60.74% across the three conditions for the factual questions (*M* = 60.74%; *SD* = 0.02) and an average accuracy score of 48.88% across the three conditions for the inferential questions (*M* = 48.88%; *SD* = 0.13).An average accuracy score of 63% was obtained for the ten factual questions and 40% across the five inferential questions during the 0% AI-PP condition. The accuracy scores ranged from 33–89% (M = 67% and SD = 0.20) for the ten factual questions, and from 0–89% (M = 44% and SD = 0.36) for the five inferential questions. Participants obtained an average accuracy score of 59% across the ten factual questions and 64% across the five inferential questions during the 50% AI-PP condition. The accuracy scores ranged from 22–100% (M = 67% and SD = 0.25) for the ten factual questions, and from 33–89% (M = 67% and SD = 0.20) for the five inferential questions. Participants obtained an average accuracy score of 60% across the ten factual questions and 42% across the five inferential questions during the 100% AI-PP condition. The accuracy scores ranged from 33–89% (M = 67% and SD = 0.18) for the ten factual questions, and from 22–56% (M = 44% and SD = 0.12) for the five inferential questions.

Discussion

This study was an introductory step to investigate how AI-PP can support auditory comprehension of narratives for persons with Wernicke's aphasia. By focusing on Wernicke's aphasia, the results of this study aid and expand the findings on narrative comprehension made by Wallace et al. (2012) and Dada et al. (2019). The results of the study are next discussed in terms of (a) the resource allocation theory, (b) individual participant characteristics, and (c) type of questions.

The resource allocation theory

As there was an increase in average accuracy scores when the frequency of AI-PP was increased in the Dada et al. (2019) study, and between the 0% and 50% conditions in the current study, one would expect the highest average accuracy score in the current study's 100% AI-PP condition. However, four of the nine participants gave more accurate responses to comprehension items in the 50% AI-PP condition, three gave more accurate responses in the 100% AI-PP condition, and two participants scored the same in the 50% and 100% conditions, as well as in the 0% and 50% conditions. The majority of the participants, therefore, achieved the highest accuracy scores in the 50% AI-PP condition. The average accuracy score was also the highest in the 50% AI-PP condition (60.74% correct answers). The average response accuracy of the 100% AI-PP condition was only 54.07%, resulting in a lower average accuracy score than those of the 0% or 50% AI-PP conditions.

What this may imply, is that AI-PP as a means to support narrative auditory comprehension tasks seems to improve auditory comprehension of narratives for some persons with Wernicke's aphasia. This is in line with Dietz et al. (2014), who supported the idea that pre-task stimulation is beneficial for comprehension, and with Wallace et al. (2018) who supported the notion of combining modalities for improved comprehension for the PWA. However, the presence of PCS system for each oncept in the paragraph combined with the high context items (in this case 100%) may be disadvantageous to the auditory comprehension of narratives for some persons with Wernicke's aphasia. That is, processing the PCS symbols and high context images at the same time may take too many cognitive resources. Much of the research suggesting multimodal approaches to be advantageous for people with aphasia have tested multiple, but different modalities presented. The same resource allocation theory that could help explain why augmented input may be beneficial for auditory comprehension could be used to explain why too much augmented input or too much of a single modality may be detrimental. During the 100% AI-PP condition, the attentional demands of the tasks increased (e.g., all the PCS pictures may be distracting; there may be too much to look at during the task of listening to the narrative). Narrative 3 with the

100% AI-PP might therefore have been too "attention demanding" (McNeil et al., 2004, p. 540), and may have led to a significant disruption in auditory processing (Murray et al., 2006).

Individual participant characteristics

The current study focused only on persons with Wernicke's aphasia, while Dada et al. (2019) and Wallace et al. (2012) included persons with different types of aphasia in one study. Dada et al. (2019) and Wallace et al. (2012) found that PWAs with less severe auditory comprehension difficulties performed more accurately overall in comprehension tasks than those participants with more severe ratings of aphasia. This was not the case in the current study, as the participant with the second highest auditory verbal comprehension score on the WAB-R had the lowest response accuracy score across all three conditions. The three participants with auditory comprehension scores below 6 also scored similarly to two participants with a score over 6. The fact that the participant population of the current study was more homogenous could explain why their auditory comprehension scores did not influence their response accuracy as much as was the case in the aforementioned studies.

Further individual analysis revealed that Participant 2 had the highest accuracy scores across all three conditions, even though four other participants presented with higher auditory comprehension scores than his. This participant was the only one with a postgraduate qualification, which possibly contributed to his higher accuracy scores. According to Laska et al. (2011), PWAs with higher education levels are inclined to fare better with speech and language therapy outcomes.; however, these results have not been replicated across other studies. Additionally, Participant 2 was also one of only two participants who were receiving speech therapy intervention at the time, which could well have contributed to his higher-than-expected accuracy scores. Of note, the other participant enrolled in speech therapy intervention obtained the second highest accuracy scores. It is largely agreed that PWAs will demonstrate greater recovery if they receive intervention (Basso & Caporali, 2001; Basso & Macis, 2011; Pulvermuller & Berthier, 2008).

Linguistic competence was especially important for the current study as the participants would need to understand the language code of the augmented input – in this case the no-context PCS images – to effectively benefit from it (Light & McNaughton, 2014). An aspect of acquiring linguistic competence is receptive and expressive skills, aspects that are targeted during Participant's 2 therapy.

The lack of a pattern between the auditory comprehension and task accuracy scores could be explained by the complex influence of bilingualism. In the Wallace et al. (2012) study, all the participants had English as their first language and in the study by Dada et al. (2019) most participants' home language was English (nine out of 12). It is unclear how many of the participants in these two studies were bilingual. In the current study, only three of the nine participants used English as their home language. However, all the participants were reported to be proficient in two languages, which is expected, given the multilingual South African context (Coetzee-Van Rooy, 2018). There is some empirical evidence to suggest that bilingualism may be associated with better cognitive outcomes post-stroke and lower severity scores on some aphasia measures (Paplikar et al., 2019). Regardless, both varied premorbid English proficiency and possible linguistic and cognitive benefits of bilingualism should be acknowledged as potential reasons why the auditory comprehension scores did not influence response accuracy in the current study (compared to previous studies).

Type of questions

Similar findings in the studies by Dada et al. (2019) and Wallace et al. (2014) make it clear that PWAs presented with higher accuracy during comprehension items related to factual stimuli, in comparison to inferential stimuli. The current study contributes to this finding by concluding that the same can be found regarding persons with Wernicke's aphasia specifically. Interestingly, the average accuracy scores of the factual questions were all within 3% of each other across the three conditions. However, there was a 26% jump in average accuracy scores from the 0% condition to the 50% condition when focusing on inferential questions specifically. Thus, AI-PP as a means of supporting narrative auditory comprehension tasks seems to facilitate improved auditory comprehension of inferential information for some persons with Wernicke's aphasia. This finding provides a starting point for continued research into the forms of support that can improve comprehension of inferential information for persons with Wernicke's aphasia.

Clinical implications

This study found that supporting narrative auditory comprehension tasks with high-context images as augmented input and no-context PCS images and keywords as AI-PP – used as pre-task and during-task stimulation – seems to improve auditory comprehension of narratives for some persons with Wernicke's aphasia. This issupported by similar findings by previous studies for PWA (Dada et al., 2019; Wallace et al., 2012). The unique contribution of this study is that it is one of only a few studies that focuses exclusively on Wernicke's aphasia. In fact, it is only the second study that focuses on the effect (at varying frequencies) of AI-PP on the auditory comprehension of narratives for PWA, and the first to focus specifically on Wernicke's aphasia. Unlike this previous study of PWA, providing AI-PP for all the content units of a narrative sometimes seems to have a negative effect on people with Wernicke's aphasia's auditory comprehension. Still, providing AI-PP for half of the content units of a narrative is more beneficial than providing no augmented input for some people with Wernicke's aphasia. Therefore, the frequency of the provided AI-PP is an important variable that influences auditory comprehension of persons with Wernicke's aphasia. . There is a strong focus on the use of pre-task stimulation, which current literature has proposed to be a vital consideration during comprehension tasks (Dietz et al., 2014; Wallace et al., 2012). A further strength of this study is the use of both linguistic and visual supports as augmented input. Research has shown that communication partners who use multiple modalities to support comprehension during interactions with the PWA generally improve the quality of the interaction (Garrett & Beukelman, 1995; Lasker et al., 1997).

Overall, this study is a preliminary step in investigating how partner pointing to augmented input can support some advances in auditory comprehension of narratives for people with Wernicke's aphasia. There was no obvious pattern to confirm that participants with less severe auditory comprehension difficulties had a more accurate response than those participants with more severe auditory comprehension difficulties. On the whole, however, participants performed better during the 50% than during the 0% or 100% conditions. In addition, it was found that the participants with Wernicke's aphasia generally presented with higher accuracy during comprehension items related to factual stimuli, in comparison to those related to inferential stimuli. Nevertheless, when looking at the inferential questions in isolation, the participants did significantly better during the 50% AI-PP condition than during the 0% AI-PP condition.

Limitations and future directions

A small sample size was the main limitation of the study, as only nine participants with

Wernicke's aphasia took part in the study. Findings from previous studies (Dada et al., 2019; Dietz et al., 2009) also suggest that a small sample size may have contributed to a lack of significance in the findings. The strict selection criteria resulted in a specific population of participants and required a challenging recruitment process. Due to the small sample size, the results of this study have restricted generalisability and interpretation of the results should be approached with caution. It is noteworthy that a limitation of the study design is that it does not account for participant fatigue. Three narratives in a single sitting, regardless of the breaks, may likely influence the results and should be considered.

Furthermore, although all the participants were reported to be proficient in English, only three of the nine participants used English as their home language. There is very limited research examining the use of AI in people who are bilingual or multilingual; therefore, it is unknown how language profiency or use may affect the results. It is possible that a greater cognitive load is required to comprehend information that is in a less familiar or less frequently used language (Ito et al., 2018). If so, people may derive even greater benefit from AI, particularly in a language neutral format such as an image. Future research should attempt to quantify language proficiency of participants to rule it out as a confounding variable and expand knowledge regarding the use of such supports in bilingual or multilingual populations.

It is recommended that the study be replicated with a larger sample of adults with Wernicke's aphasia to ensure a more robust statistical analysis. This study could also be replicated using participants of other aphasia types to determine what frequency of augmented input best supports differing types and severities of aphasia. This is necessary to establish an evidence base to inform clinical practice regarding the type of augmented input that is beneficial for whom and under what circumstances (Wallace et al., 2018).

Last, it is recommended that – instead of using the PCS images – the study be replicated using photographs or personal images to examine the effect that such visual supports have on the auditory comprehension of persons with Wernicke's aphasia during narrative tasks (McKelvey et al., 2010).

Conclusion

These findings suggest that supporting narrative auditory comprehension with augmented input, via pre-task and during-task stimulation, improves the auditory comprehension of narratives for some persons with Wernicke's aphasia. Future research should expand on these findings to determine the types and frequency of augmented input that will enhance auditory comprehension for persons with aphasia, specifically Wernicke's aphasia.

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