Amplification for People with Aphasia

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AMPLIFICATION FOR PEOPLE WITH APHASIA

by

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ABSTRACT

Deficits in auditory processing and comprehension can have negative impacts on everyday conversation in people with aphasia (PWA). Comprehension deficits observed in people with aphasia have been compared to individuals with auditory processing disorder (APD). Koohi and colleagues (2017) found that individuals with auditory processing disorder (APD) post-stroke benefitted from use of amplification as it related to their deficits in auditory processing. This preliminary study aims to determine if PWA will benefit from amplification on measures of comprehension and in a broader sense, use of amplification in everyday life. Nine adults with expressive aphasia and 5 neurologically normal controls were administered listening tasks with and without amplification in a structured environment. Results indicated that amplification had a small positive effect on PWA and a moderate-large positive effect on control participants, as it relates to their overall comprehension of discourse. Amplification may help to lessen the demand on processing auditory information and be a potential tool in facilitating discourse comprehension for particular PWA. Further research is needed to determine potential benefits of amplification use by PWA.

INTRODUCTION

Aphasia is an acquired disorder that impacts production and/or comprehension of language. Auditory speech comprehension deficits significantly affect social interactions, independence, and life participation. Aspects of auditory comprehension can be differentially impacted by acquired brain injury and one's capacity for attention and resource allocation. Similar to aphasia, APD affects the ability to understand speech in absence of hearing loss. Amplification has been used effectively with individuals with APD, and current literature suggests that amplifying auditory input may be beneficial for people with aphasia (PWA) with auditory processing deficits. Yet, there is no current research available regarding how amplification might affect speech comprehension in PWA.

Amplification for auditory processing disorder

ASHA (2014) states that APD refers to limitations in audible signal transmission, analysis, organization, transformation, elaboration, storage, retrieval and use. People with APD may exhibit difficulty following directions, discriminating similar-sounding speech sounds and understanding speech in noisy environments. Treatment typically targets three major components: remediation of auditory deficits, changing the communicative environment, and compensating for the disorder (ASHA, 2014). Environmental modifications such as auditory amplification improve access to auditory information and often mitigate the impact of APD (Johnston, John, Kreisman & Hall, 2009) and are a recommended approach for many of those with auditory processing difficulties (ASHA, 1994a). Amplification boosts intensity, or loudness, of the auditory signal and improves signal quality. Personal frequency-modulated systems (FMs) provide a form of amplification wherein they transmit a speaker's voice to a receiver in the listener's ear, which reduces negative effects of reverberation, distance and noise. Johnston et al.

(2009) conducted a study involving 10 children with APD and normal hearing sensitivity to investigate potential speech-perception and psychosocial function benefits of a new personal FM system when used in classroom environments. Participants were provided miniaturized ear-level FM systems during all lecture-based activities. Improvement was noted in both quiet and noise conditions with 2.02 dB and 11.91 dB increases respectively. Participants also reported increased levels of emotional and psychological health post-FM system use (Johnston et al., 2009). Stach, Loiselle, Jerger, Mintz and Taylor (1987) reported similar results when they observed academic gains for 11 children with APD when fitted with FM technology. Smart, Kelly, Searchfield, Lyons and Houghton (2007) conducted research to determine impacts of low-gain open-fit hearing aids coupled to an FM system on participants with APD and normal peripheral hearing. Participants noted a marked improvement in auditory perception. Improvement was exhibited on informal patient questionnaires as well as test results including Dichotic Digit Test (Smart et al., 2007). However, investigators noted that test results were influenced by participants' ability to effectively attend and their overall motivation during the assessment. Overall, while research related to amplification for individuals with auditory processing disorders is limited, results indicate that amplification has a net positive effect on participants' ability to better manage auditory signals. Deficits associated with APD may co-occur with other disorders including aphasia.

Auditory comprehension deficits in PWA

Comprehension of spoken words and sentences requires integration of auditory information in speech with previously stored semantic representations of words in semantic lexicon (Weber & Scharenborg, 2012). However, PWA often exhibit difficulties with auditory word comprehension comparable to those with APD, which is characterized by semantic and phonological deficits. Traditionally, aphasia is divided into two major sub-types: fluent aphasia (Wernicke's-type) and non-fluent aphasia (Broca's-type). Ardila (2012) described that fluent aphasia is associated with impairments of the lexical-semantic system of language. Kemmerer (2015) noted that fluent aphasia is linked to language comprehension deficits coupled with deficits in phonological, lexical and semantic language systems and is associated with pathology of the temporal-parietal lobe in the dominant left hemisphere. Site of lesion predicts type of auditory word comprehension deficit including: pure word deafness, word meaning deafness, word meaning aphasia, and sentence comprehension deficit (Imaezue & Salako, 2017). Auditory word comprehension deficits are characterized by poor repetition of speech or single words, paraphasias, poor speech comprehension, phonemic retrieval deficit and semantic access deficit (Ardila, 2010). PWA with auditory word comprehension impairment may have difficulty recalling from semantic memory and relating words to specific meanings (Breese & Hillis, 2004). Thompson, Robson, Lambon Ralph, and Jefferies (2015) explained that cases of auditory word comprehension deficit can vary greatly from impaired comprehension of commands or single words to understanding only a few words or statements. A case study by Kumar, Mohan, Pavithra and Naveen (2016) examined two individuals with non-fluent aphasia. Their findings indicated "abnormal representation of acoustic stimuli at brainstem and cortical levels," which is commonly associated with central auditory processing disorder (CAPD) (Kumar et al., 2016, p. 137). Kumar et al. (2016) concluded that CAPD may be prevalent amongst some individuals with non-fluent aphasia and should be considered during assessment. There are currently three primary types of aphasia treatment for auditory word comprehension deficits including: impairment-based approaches, consequence-based approaches and direct electrical stimulation approaches. Research have reported that impairment-based and direct electrical stimulation approaches are effective at targeting auditory comprehension deficits in PWA (Waumbaugh, Doyle, Martinez, & Kalinyak-Fliszar, 2002; Jefferies & Lambon Ralph, 2006). While aphasia recovery varies from person to person and is contingent upon many factors including effective treatment, auditory comprehension deficits caused by stroke are never fully remediated. Thus, additional measures to mediate auditory comprehension deficits from stroke should be researched and implemented.

Cognitive load: attention and resource allocation

Auditory comprehension does not occur in isolation; rather it is affected by other cognitive functions including attention and executive function. Miyake, Friedman, Emerson, Witzki, Howerter and Wager (2000) state that executive function refers to an unspecialized control mechanism that regulates and manages operation of assorted cognitive subprocesses; in turn, regulating much of human cognition. Ramsberger (1994) noted that one's executive functions play a pertinent role in conversation as a person needs to be able to attend to a communication partner, sequence information to be communicated, monitor communication and adapt strategies to facilitate ongoing conversation. Miyake et al. (2000) also iterate the importance of executive functions in language processing including attention switching, inhibition, and working memory (WM) updating and monitoring. These aspects of conversation may be impaired in PWA. Salis (2011) stated that online storage and computation of syntactically complex sentences may lead to increased error rates due to potential overtaxing and/or inefficient allocation of WM resources. These types of errors may be magnified in PWA due to deficits in executive function and language. Resource allocation is the process by which cognitive resources are allocated to brain systems for different tasks. Research by McNeil, Odell and Tseng (1991) suggested that resource allocation in aphasia is not reduced, but rather is inefficient. Inefficient allocation of attention resources and diminished capacity of attention has been demonstrated in PWA, which may underlie language deficits in this population (Murray, Holland & Beeson, 1997a). Frazier and Friederici (1991) stated similarly that agrammatic comprehension is more of a computational deficit rather than conceptual one, which may lead to uneven performance on sentence comprehension tasks due to varying sentence structures and tasks. Findings by Caplan, Baker and Dehaut (1985) also suggested that PWA have impaired syntactic comprehension largely due to insufficient processing resources. Murray, Holland and Beeson (1997b) noted decreases in auditory processing effectiveness when PWA were required to make lexical decisions and semantic judgments during attention tasks. Kohen, Martin, Kalinyak-Fliszar, Bunta, and Dimarco (2007) found that PWA's performance on semantic judgment tasks declined significantly as verbal WM load increased. In a follow-up study, researchers implemented two additional similarity judgment tasks pertaining to synonymy and rhyming wherein they again discovered significantly reduced accuracy in performance with increases in verbal WM load (Martin, Kohen, Kalinyak-Fliszar, Soveri, & Laine, 2012). Language processing and verbal WM may also be impacted by one's capacity for various executive processes. Effective allocation of resources including attention is also influenced by the degree of salience of the stimulus and listening context (Feldman & Friston, 2010). Thus, it is imperative that one differentiates between discourse comprehension and isolated-sentence comprehension in regard to PWA's overall capacity for auditory comprehension.

Narrative discourse comprehension and isolated-sentence comprehension

PWA's capacity for effective resource allocation may vary across auditory comprehension tasks including narrative discourse and isolated-sentence comprehension as they are also contingent upon effective allocation to their respective cognitive processes. Discourse comprehension is not simply contingent upon understanding a grouping of sentences or propositions within it. Rather, intended meaning of discourse is derived from the relationships among propositions (Frederiksen, 1977). Salis (2011) also stated that propositions between sentences are building blocks of discourse, which facilitate the meaning of propositions that comprise that discourse. Brookshire and Nicholas (1997) stated that PWA's capacity for discourse comprehension is impacted by saliency and explicitness of information within discourse as well as the rate and stress in which it is presented. Thus, discourse comprehension may be impacted by inferential processing as well as presentation rate of discourse and semantic density of propositions (Stine, Wingfield & Poon, 1986; Ulatowska, Hayashi, Cannito & Fleming, 1986). Discourse may also communicate a temporal order of events, which is integral to comprehension (Salis, 2011). However, PWA still possess lesser discourse comprehension skills in comparison to typical peers. PWA's capacity for isolated-sentence comprehension is primarily contingent upon general auditory comprehension and lexicosemantic abilities. WM has also been noted to play a key role in the differences of sentence-processing ability between simple and complex structures (Salis, 2011). Amount of lexical items and more specifically distance between key words related to comprehension have a significant impact on the overall capacity necessary for sentence comprehension (Martin & Romani, 1994). Martin and Romani (1994) iterated further that effective semantic and syntactic retention are important to adequate isolated-sentence comprehension. PWA may have deficits in syntactically based comprehension wherein PWA have difficulty with sentences where either noun phrase could play either thematic role around the verb or when sentences have a noncanonical word order (Grodzinsky, 1989; Levy, Hoover, Waters, Kiran, Caplan, Berardino & Sandberg, 2012). Discourse comprehension and isolated-sentence comprehension vary both in demands on cognitive resources as well as in type of processes necessary for effective comprehension. Processes necessary in comprehending isolated-sentences are not equally important in discourse comprehension (Brookshire & Nicholas, 1997). Moreover, performance on measures of comprehension of isolated-sentences may indicate auditory processing difficulty, but such outcomes are not typically indicative of the listener's ability to comprehend contextually supported discourse. PWA frequently seem to understand discourse better than expected given their impairments with words and sentences (Brownell, 1988). Other studies have also confirmed that PWA typically more easily understand sentences placed at ends of sentences placed at ends of contextual paragraphs rather than isolated sentences (Cannito, Vogel & Pierce, 1991). Cannito et al. (1991) iterate that these preceding passages help to clarify and further one's understanding of the particular meaning of a single sentence. Discourse comprehension requires an individual to be able to extract meaning from each individual sentence and integrate that meaning into context provided by surrounding sentences within discourse (Brownell, 1988). Overall, impairments in isolated-sentence comprehension will have a negative effect on discourse comprehension, but the most important processes and cognitive resources for the two types of comprehension differ respectively.

Amplification for patients post-stroke with auditory processing deficits

Effective auditory processing and comprehension requires an adequate auditory signal. However, those with auditory processing difficulties may require amplification to better process auditory information. Koohi, Vickers, Warren, Werring and Bamiou (2017) conducted a related study to determine benefits of FMs use in individuals with non-aphasic stroke and auditory processing deficits, but typical hearing. Five participants received standard care, whereas the other four participants received intervention that involved implementation of (FMs) in their daily life over a 10-week period. All four intervention subjects were provided the Phonak iSense

Micro receiver and ZoomLink+ transmitter, which were set proportionately based on noise level at the microphone of the FM system (Koohi et al., 2017). Primary tool for assessing outcomes of the study was the Bamford-Kowal-Bench (BKB) sentence test, which was presented in a sound-attenuated booth. Koohi et al. (2017) found that there were statistically significant improvements post-intervention in speech reception threshold (SRT) in noise both with and without amplification across all subjects that received intervention using FMs. Authors of the study hypothesized that 10-week use of FMs by individuals with stroke may lead to better noise perception in unaided speech. They also stated that their findings may indicate auditory plasticity type changes within the brain when provided amplification. Overall, this study establishes that amplification on typically hearing individuals post-stroke with auditory processing difficulties may be an effective tool for facilitating better auditory comprehension.

Findings by Koohi et al. (2017) suggest that amplification of auditory input may also be beneficial for PWA with auditory processing deficits, but typical hearing. However, limited research is currently available regarding how similar individuals who also have aphasia may improve on measures of comprehension given amplification. The purpose of this study is to explore the impacts of amplification for PWA with auditory comprehension deficits and typical hearing. Expected outcomes are that PWA will differ on level of improvement on measures of comprehension with amplification based on type of aphasia and that PWA will improve on all measures of comprehension with amplification in comparison to performance on measures of comprehension without amplification. Furthermore, it’s expected that PWA will have greater improvements on Discourse Comprehension Test (DCT) when provided amplification in comparison to performance on Revised Token Test (RTT) given amplification. As noted above, narrative discourse comprehension and isolated-sentence comprehension are fundamentally different, and DCT and RTT assess these components of comprehension respectively. Narrative discourse comprehension is more contingent upon the listener's ability to understand relationships between statements and effectively make inferences (Ulatowska et al., 1986). Narrative discourse provides context for words and sentences that PWA may otherwise have difficulty comprehending in isolation (Cannito et al., 1991). Sentences and commands given in isolation provide less in the way of context and are more heavily contingent upon strictly effective auditory comprehension (Martin & Romani, 1994). As previously stated, Brownell (1988) noted PWA frequently seem to understand discourse better than expected given their impairments with words and sentences. Thus, it is hypothesized that PWA will show greater improvements in measurements of discourse comprehension given amplification, as PWA are seemingly predisposed to have better discourse comprehension respectively in comparison to isolated-sentence comprehension and comprehend better when hearing sentences in context. Lastly, it's expected that PWA will benefit more from amplification than control participants on comprehension tasks, as control participants have no impairment to their neurological function.

METHODS

Participants

All participants were recruited on a volunteer basis from the Fontbonne University community through fliers, email and word-of-mouth. Potential participants were screened using criteria mentioned below and placed in the appropriate group for participation in the study. Ten adults (6 males, 4 females) were recruited as participants for the experimental group (see Table 1). Participants ranged in age from 53 years old to 77 years old. All participants were screened and met the following selection criteria: positive for expressive or receptive aphasia due to stroke, negative for global aphasia based on Western Aphasia Battery-Revised (WAB-R) scores, and no hearing loss at 1, 2 and 4 kHz greater than 45 dB hearing loss (HL) with a mean HL of 35 dB or lower. Five adults (1 male, 4 females) were recruited as the control group. Participants in this group ranged in age from 58 years old to 68 years old. All participants in the control group were screened and met the following criteria: negative for history of neurological injury/disorder as determined by self-report and passing Short-Blessed Test (SBT) and no hearing loss at 1, 2 and 4 kHz greater than 45 dB HL with a mean HL of 35 dB or lower. Requisites related to hearing loss were established to mitigate potential confounding variables and to account for presbycusis.

Materials

DCT and RTT are auditory comprehension measures used to determine the impact of amplification on PWA. DCT is a systematic and sensitive assessment for individuals with brain damage that assesses comprehension and retention of stated and implied main ideas and details. RTT is a sensitive quantitative and descriptive test battery for determining auditory processing inefficiencies including deficits in direction following associated with aphasia, brain damage and other particular language and learning disabilities. Assorted tools were utilized in setting up the testing environment and determining appropriate candidates for testing. Zoom H4 Digital Recorder was utilized to record a male graduate student's reading of all subtests within RTT. Male graduate student's reading of RTT was intentionally monotonous and utilized because his voice would be more comparable to the pre-recorded male voice for DCT than a female's voice. All levels in the testing environment were made at dBA relative to 0 dB SPL. Quest Electronics Model 215 Sound Level Meter was utilized to measure volume of the Logitech Mini Boombox Bluetooth speaker respective to the iPad's (32 GB, 6th Generation) volume control. The iPad was set at 5 bars of volume (baseline condition) and 13 bars of volume (amplification condition), which corresponded with 65 dB SPL and 85 dB SPL respectively. The iPad was utilized to play all recordings of DCT and RTT, and Grason-Stadler Model GS-61 was utilized to conduct all audiological screening. Short-Blessed Test was administered to screen out potential control participants that may be exhibiting some type of cognitive dysfunction. WAB-R bedside screener was administered to determine if any potential experimental participants may have deficits indicative of global aphasia.

Procedure

Written consent was obtained from all participants. Participants within the experimental group were required to take WAB-R Bedside Screener to eliminate participants with potential global aphasia. SBT was administered to all control participants via phone to identify potential red flags regarding cognitive function. All hearing screenings were conducted in the same audiological booth by the same audiologist. Hearing was screened at 1, 2 and 4 kHz for both left and right ears. If participants passed the hearing screening, they moved on to auditory comprehension assessments. Auditory comprehension assessments were conducted by 2 graduate students and 1 practicing SLP. Measures were administered in two similarly-structured therapy rooms with marked locations for table, chairs, Bluetooth speaker and testing materials. Time necessary to complete each individual assessment was recorded using a timer. Timing of assessments included recorded production of test materials and participant responses. If participants were unable to complete the practice set/initial introduction, that particular assessment was not administered. Test order (RTT, DCT Form A, DCT Form B) and condition order (baseline, amplification) were counterbalanced. Baseline condition was set at 65 dB SPL and amplification volume was set at 85 dB SPL. DCT was administered via typical testing protocol. All portions of DCT including practice stories were conducted using Bluetooth speaker. Six seconds were subtracted from Form A stories to allow for fair, accurate comparison of time taken to complete respective stories between alternate Form A and B. First half of each RTT subtest was administered as it was determined it would help to mitigate participant fatigue and adequately represented the other half of each respective subtest. The test administrator delivered pretest instructions verbally. All other portions of RTT were conducted using Bluetooth speaker. Only RTT scores 15 through 9, 7 and 5 were available to earn. This was done to facilitate testing efficiency across participants and administrators. Following administration of all tests, participants were asked about their perception regarding preference and ease of listening on baseline and amplification conditions on both DCT and RTT. Participants were then provided compensation in the form of a gift card upon completion of assessments.

RESULTS

Independent and paired samples two-tailed T-tests were utilized to address previously stated theoretical expectations along with assessing the significance of difference between and within groups across test conditions. Cohen’s d effect sizes were also determined in consideration to theoretical expectations and amplification condition’s effect on outcomes.

One outlier from the experimental group was excluded from results. During administration of RTT and DCT, this participant stated that she was guessing intermittently. Thus, her outcomes may have been indicative of chance, rather than her actual capacity for auditory comprehension with and without amplification. Considering the relatively small sample size (n=10), the outlier had significant impact on findings. It was decided to exclude her data from analyses, as it fell more than 2 standard deviations from the rest of the experimental group's mean gains given amplification on DCT. Also, one participant from the experimental group did not complete RTT, as he was unable to correctly identify shapes and colors consistently during the practice/introductory set. All other participants completed all assessments.

Two-tailed T-tests revealed no statistically significant differences between experimental and control group scores in baseline and amplification conditions. Two-tailed T-tests also revealed no statistically significant difference found between experimental and control group scores in the baseline condition on DCT. However, there were statistically significant differences found between experimental and control group scores in both baseline and amplification conditions. With that being said, no statistically significant differences were found within groups between scores in baseline and amplification conditions on either RTT or DCT.

To further delineate these findings, Cohen's d effect sizes were calculated within groups comparing scores in baseline and amplification conditions. Regarding RTT, no significant effect was found within either experimental or control groups between scores in baseline and amplification conditions. However, significant effect was found related to scores on DCT (see Figure 1). Amplification condition had a small effect (d=.2) on experimental group scores on DCT and had a moderate-large effect (d=.7) on control group scores on DCT.

To further differentiate between participants' outcomes, results of those PWA that benefitted most from amplification (n=4) were isolated and effect sizes were determined for each component of DCT within this group between scores in baseline and amplification conditions (see Table 2 & 3). Amplification condition had small effect (d=.3) on stated main ideas, large effect (d=.8) on implied main ideas, and large effect (d=.8) on main ideas as a whole.

Amplification condition also had a moderate effect (d=.5) on stated details, small-moderate effect (d=.4) on implied details, and a small-moderate effect (d=.4) on details as a whole.

Hearing, age, gender, condition order and test order had no significant impact on findings.

DISCUSSION

The only significant differences found between PWA and control participants were in baseline and amplification conditions on RTT. However, amplification condition had moderate-large effect on control participants and small effect on PWA on discourse comprehension. For PWA that exhibited the greatest gains from amplification (n=4), amplification condition had small-large effect across all aspects of discourse including stated and implied main ideas and details. Amplification increased participant's score over the cut-off value (2 standard deviations below the mean) on DCT, indicating that amplification was the difference between functional discourse comprehension and potentially disordered discourse comprehension per DCT scoring protocols. As predicted, amplification had greater effect in regard to outcomes on DCT rather than RTT for PWA. However, there was no effect observed with RTT across groups in relation to amplification.

In comparison to PWA, a greater effect was seen within the control group regarding amplification. Regarding these findings, limited impact of amplification on RTT outcomes may be due to PWA's increased difficulty with completing the assessment, evidenced by increased length of test times and overall larger discrepancies between PWA and control scores on RTT compared to DCT. In contrast, ceiling effects were observed in the control group. Mean scores reached 14 out of 15 (15 being the maximum score) or higher in baseline condition, so gains related to amplification were impossible to observe. Time to complete RTT varied across participants with no statistically significant differences between baseline and amplification conditions. Future studies may look further into impact of latency on outcomes comparing performance with and without amplification. In relation to the greater effect observed within the control group regarding implementation of amplification and DCT, this may be due to respectively smaller number of participants (n=5) and/or other potential unidentified characteristics within participants.

Lack of statistical difference may be due to lower number of participants and potential unforeseen confounding variables. Additional statistical analyses revealed no identifying factors regarding why amplification had greater effect on some PWA than others. Hearing, age, gender, condition order and test order were ruled out as factors that had an impact on findings from a statistically significant perspective. However, sample size may have impacted these findings as well and potentially with a larger sample size, factors may be more readily identifiable regarding their impact on amplification's effect on PWA's discourse comprehension. As expected, PWA seemingly benefitted from context of narrative discourse, as their scores were comparably higher on DCT in both baseline and amplification conditions with there being no statistically significant difference between control participants on DCT in the baseline condition.

Although there were no statistically significant findings based on T-tests, small positive effect sizes were observed within the experimental group. Moderate-large effects were identified in PWA that exhibited the greatest benefit from amplification condition (n=4) . Regarding those PWA that achieved benefit from amplification, it is postulated that amplification may have alleviated some of the demand on the general pool of cognitive resources available allowing them to more effectively attend to and process auditory information. This, in combination with the salience and context of narrative discourse, may have allowed for gains with amplification.

This account is consistent with McNeil et al. (1991) that proposed that PWA possess an inefficiency regarding allocation of cognitive resources. Such inefficiency can be further impacted as cognitive and verbal demands increase (Kohen et al., 2007). Martin and Romani (1994) affirmed that isolated sentences, rather than discourse are more heavily contingent upon strictly auditory comprehension.

Subjective reports

Seventy-five percent of those PWA that saw benefit from amplification voiced that it was easier to listen in the amplification condition. This finding was respectively higher in comparison to the rest of the experimental group, where 20% percent of participants stated it was easier to listen to the amplification condition. Perception of the experimental group and positive effects observed within this study along with previous findings by other researchers potentially indicate that amplification may alleviate some demand on cognitive systems of those PWA that saw benefit.

This is the first study to investigate potential benefits of amplification for PWA with auditory comprehension deficits, but typical hearing. However, this study has limitations. The study has a relatively small number of participants, so findings should be interpreted with caution. Low study numbers can affect accuracy of measurements and findings may not reflect a true effect (Deeks, Dinnes & D'Amico, 2003). Furthermore, participants were not randomly selected, which may have influenced outcomes. Another limitation is that the effect of extent of brain lesion was not fully investigated. Brain lesion type and severity may have a direct or indirect relationship with how amplification may affect a PWA's ability to comprehend auditory information and discourse. Within this study, all PWA had expressive, non-fluent aphasia. Due to this along with a relatively small sample size, it was unfeasible to compare aphasia subtypes statistically. More in-depth analysis of the impact of amplification across aphasia subtype and severity will help to facilitate a more accurate determination of the impact of amplification on the wider population of PWA. The outcomes presented here should motivate further work targeting the general effects of amplification on PWA via a larger study to investigate broader benefits of amplification. Additional research may be dedicated towards effects of amplification on individuals with receptive aphasia, as they were not assessed within this study. Overall, future research is required to explore amplification as an adjunctive to speech therapy intervention for PWA.

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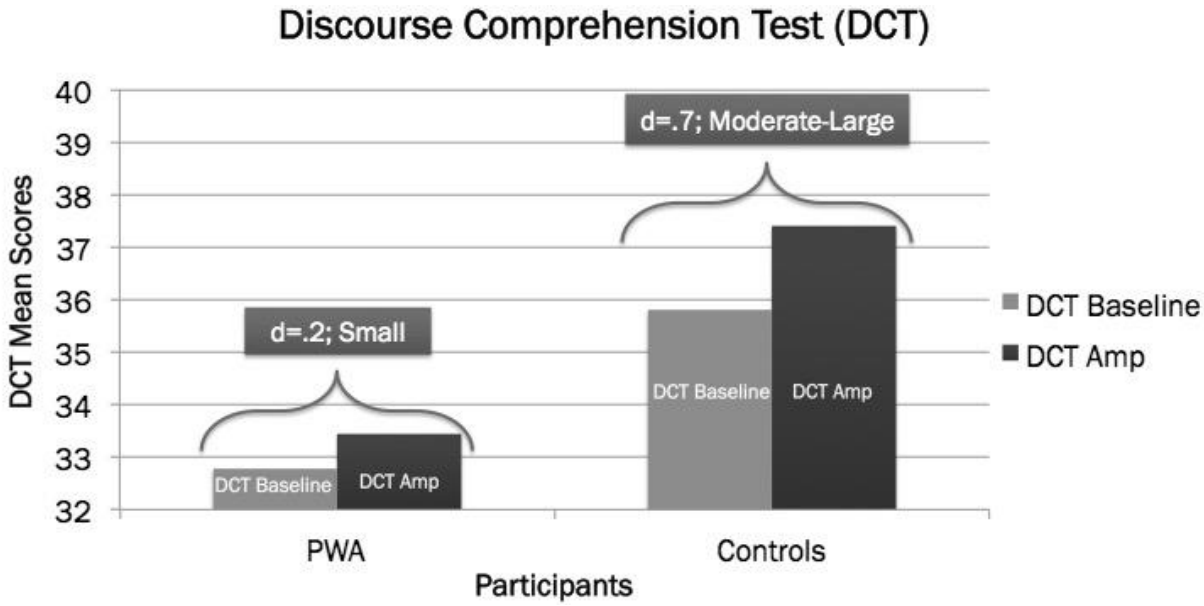

Figure 1. Illustrates DCT mean scores of experimental and control participants with amplification (Amp) and without amplification (Baseline) along with amplification condition's effect (Cohen's d) on each group respectively.

Table 1

People with Aphasia (PWA): Descriptive Information

Age	Gender	Hearing Average (1, 2 & 4 kHz)	Aphasia Category	Aphasia Sub-type	Severity
63	Male	14.17	Expressive	Non-fluent	Mild
77	Male	19.17	Expressive	Non-fluent	Mild
63	Male	13.33	Expressive	Non-fluent	Mild
58	Female	16.67	Expressive	Non-fluent	Mild
60	Male	10	Expressive	Non-fluent	Mod-Sev
54	Female	14.17	Expressive	Non-fluent	Mild
53	Male	6.67	Expressive	Non-fluent	Mod-Sev
56	Male	6.67	Expressive	Non-fluent	Mod-Sev
57	Female	8.33	Expressive	Non-fluent	Mild

Presents descriptive information of experimental participants including age, gender, hearing average, aphasia category, aphasia sub-type and severity (Mild & moderate-severe [Mod-Sev]).

Table 2

PWA that Benefitted from Amplification on DCT

Age	Severity	Gender	Hearing Average (1, 2 & 4 kHz)	DCT: Baseline Total Score	DCT: Amplification Total Score	Difference Between DCT Scores
77	Mild	M	19.17	29	33	+ 4
60	Mod-Sev	M	10	27	31	+ 4
54	Mild	F	14.17	36	39	+ 3
57	Mild	F	8.33	34	36	+ 2

Presents descriptive information of experimental participants including age, gender, hearing average, aphasia category, aphasia sub-type and severity (Mild & moderate-severe [Mod-Sev]).

Table 3

PWA that Benefitted from Amplification on DCT: Further breakdown

	DCT: Stated Main Idea		DCT: Implied Main Idea		DCT: Main Idea-Total		DCT: Stated Details		DCT: Implied Details		DCT: Details-Total	
	Base	Amp	Base	Amp	Base	Amp	Base	Amp	Base	Amp	Base	Amp
	9	10	8	8	17	18	8	9	4	6	12	15
	9	8	4	9	13	17	6	6	8	8	14	14
	10	10	9	10	19	20	9	9	8	10	17	19
	9	10	10	10	19	20	7	9	8	7	15	16
Effect Size	.3		.8		.8		.5		.4		.4	

Displays outcomes of PWA that benefitted most from amplification (n=4) and their performance with amplification (Amp) and without amplification (Base) on the DCT.