Extending the use of Spanish Computer-assisted Anomia Rehabilitation Program (CARP-2) in people with aphasia

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ABSTRACT

Purpose: To extend the use of the Spanish Computer-Assisted Rehabilitation Program (CARP-2) for anomia from a single case to a group of 15 people with aphasia. To evaluate whether the treatment is active (Phase 1) for this group (Robey & Schultz, 1998), providing potential explanations as to why.

Method: Fifteen participants with chronic aphasia (with a range from moderate to mild anomia) were recruited to 15 weeks of computer-assisted therapy for anomia. An ABA design evaluated participants' ability to name 200 words using the multiple cues provided by the computer. Pre- and post-naming measures of all items examined the effect of treatment. Background linguistic and cognitive skills were measured before and after the therapy to investigate whether the improvements in naming were therapy specific.

Results: All 15 participants showed significant benefits in their naming skills after the therapy. There were no changes to cognitive and linguistic skills unrelated to anomia. There was evidence of some carry-over effects in naming.

Conclusions: The Spanish Computer-Assisted Rehabilitation Program (CARP-2) for anomia is an active treatment for a range of people who have anomia as part of their aphasia profile.

INTRODUCTION

The case for treatment of naming difficulties is well supported (for summary of these see Nickels, 2002; Laine & Martin, 2006). One of the main features of such therapy is the intensity and range of stimulation methods needed (see Howard et al., 1985, Nickels 2002), hence the use of computers to provide and/or supplement face-to-face therapy for anomia. Consequently, in the last decade, there have been a proliferation of studies to examine how and what is the most useful way to use computers in anomia rehabilitation. Adrian et al. (2003) set out a list of possible advantages of computer assisted therapy over face-to-face. These included: mass exposure to items, varied range of multi-sensory tasks to provide the widest possible stimulation, participants able to control their own progress and have precise and on-line feedback about how they are doing, choice of how they carry out the therapy and with whom and a range of positive outcomes, not just in their naming ability but also in other language tasks, self esteem and adjustment to aphasia. Table 1 summarizes previous studies where some of these advantages have been found.

TABLE 1 ABOUT HERE.

From this table, it is clear that computer assisted therapy has been useful for anomia arising from a range of etiologies (CVA, dementia, TBI) and for a wide range of participant numbers (studies varied from 1 to 18 participants). Every study used a large number of items and/or exercises with a wide and varied range of tasks to stimulate both the semantic and phonological information needed to name. Multiple cueing was the most widely used method. There was more variation in whether the computer program is participant-controlled or led by a speech/language pathologist (SLP), dividing equally between assisted and unsupervised learning. Almost all programs provided precise feedback to the participant. Importantly, there was strong statistical support to back up the claims that computer assisted therapy had positive

effects on naming. Some studies also reported positive improvements on other areas such as other cognitive and linguistic skills and functional improvement and self esteem.

Given the increased use of these computer assisted programs, speech and language pathology has required a systematic way of evaluating each program. Robey and Schultz (1998) suggested a model for providing evidence of therapeutic effectiveness, outlining 5 phases of evidence. These were later modified and further specified by Wertz and Katz (2004) specifically for computer assisted therapy. In brief, those authors proposed a five-phase treatment outcome research model for computer-based interventions in aphasia: Phase 1: The purpose of Phase 1 was to show that the treatment (e.g. a computer-assisted program for anomia) was active in improving the aphasia deficits. Phase 2 refined the ideas explored in phase 1 by specifying who was more likely to improve from the therapy, to inform clinician training, to reconsider the stimuli (type and number), determine optimal intensity and duration of the treatment and sessions, establish appropriate order of tasks and stimuli and demonstrate validity and reliability of the therapy program (by detecting pre-post improvement). Phase3 tested the treatment's efficacy under optimal conditions while Phase 4 demonstrated the treatment's effectiveness. Phase 5 examined overall cost-effectiveness of a treatment, assessing outcomes beyond symptom remission and included evaluation of the participant's quality of life and family satisfaction with the rehabilitation.

This study aimed to build on the single case study report from 2003 (Adrian et al.) in order to answer the question of whether the treatment was active (Phase 1). Adrian et al.'s (2003) single case study of woman with aphasia post CVA (MRP) provided strong evidence that naming could be improved in this specific case using a computer assisted program (CARP-1). The program was based on a 'drill and practice' regime of 12 sessions, working with 60 items (40 objects and 20 items) within 5 categories; 2 nonliving: (furniture and household items), 1 living things (animals), 1 body parts and 1actions. For each target stimulus, MRP attempted to name

the item in the presence of 4 different cues which she selected herself from a choice of semantic, phonological, written and mixed. For example, to name a picture of a tiger [tigre], the semantic cue was: 'a wild animal, with striped fur'; the phonological cue was the first syllable /ti/; the written cue was the first two graphemes to indicate the first syllable and a line to show second syllable (in this instance, TI _); the mixed cue used a range of ways to stimulate the naming of the word: e.g. superordinate category, visual and contextual features of the word (e.g. scene) and closing sentences prompting familiar expressions. In Spanish, to say something smells bad, one might say 'huele a tigre' (it smells like a tiger) so the mixed cue for this example was 'huele a…' (it smells like a…). MRP not only improved on the trained items, but also after training was able to self cue such that she could name non-treated items at follow-up. This study was a single case only and what remained unclear was whether her response to the computer therapy was unique (because of her retained reading and writing skills) or whether this might be expected from all those using such a method for anomia treatment.

The current study therefore expanded on this single case pilot by increasing the number of participants who were trained from 1 to 15, with a range of anomia severities. The computer program itself included alterations to improve its appearance and to make the interface more user-friendly. The number of sessions, the number of items and range of stimuli were all increased. The decision to increase all these factors arose from a desire to provide more intense therapy over a longer period (Basso, 2005). The intensity of therapy was not just related to the frequency with which the participants studied items (twice weekly) but also to the increased task complexity (e.g. naming in the presence of different distracters) and the increased number of semantic categories. Laganaro et al. (2006) found that treatment effects depended more on the number of treated items rather than on the number of repetitions per item. Pedersen et al. (2001) suggested that all participants should go through every cue in a hierarchical order and by going through each step/cue in an incremental way, the participant would then be able to improve lexical access following the therapy. Doesborgh et al. (2004) also emphasized the

benefits of using multicues in this type of therapy, making use of semantic, phonological orthographic cues and repetition in combination, rather than in isolation. The overriding aim for the revised program was to provide a larger number of items with a wider range of multicues and a definite hierarchical structure to the tasks so that the full range of participants could be compared on the program.

METHOD

This study was approved by the ethics committee of the University of Málaga, Spain.

Treatment design

An ABA design was selected to evaluate CARP-2's ability to treat anomia. Such a design allowed a baseline period where no treatment was given (A), followed by a period when treatment was introduced (B) and then a period in which the treatment was removed so the behavior could be observed a second time (A). In this way, the study aimed to measure naming behavior before treatment, during treatment and once treatment was removed. The study used the same assessments pre and post therapy intervention to show change (A) with the treatment (B) sandwiched between the measures. There were two types of pre and post measures: Control measurements and measures of the naming therapy.

Control measurements. Each participant with aphasia was evaluated on a small set of neuropsychological assessments. These included a) picture naming which included both subtests of the Spanish version of PALPA *(EPLA 51 & 52*; Valle & Cuetos, 1995). This control measure would allow the study to show whether the learning on the computer remained item specific (Howard et al., 1985) or whether there was any carry over effects, for example, to different pictures of the same items or to untreated but semantically related pictures.

b) Raven's Colored Progressive Matrices (CRPM) (Raven, Raven & Court, 2003) provided an evaluation of problem solving and intelligence and would not be expected to alter as a result of the therapy program.

Measure of the naming therapy. Before the start of the therapy, each participant with aphasia (and their matched control) named the 200 items from the CARP-2 program. At the end of therapy (7 to 10 days later) the participants with aphasia were retested on the 200 items from the CARP-2.

Participants: inclusion criteria

The study aimed to recruit 15 people with aphasia who had the following characteristics;

- Aphasia following cerebral vascular accident (CVA: ischemic or hemorrhagic).
- Anomia (naming problems) not exclusively linked to dysarthria or verbal apraxia.
- Be at least 12 months post-onset.
- Have no concurrent neurological (e.g. Alzheimer Disease), medical (e.g. Chronic Obstructive Pulmonary Disorder, emphysema, sleep apnea or alcoholism) or psychiatric disorders (e.g. schizophrenia, bipolar disorder) which might have altered cognitive function.
- Have received no medication known to act on cognitive function (.e.g. dopaminergic agonists, GABA-agonists, antidepressants) within the month prior to the study.
- Show no visual agnosia.

Recruitment

The study included 15 right-handed individuals (11 men, 4 women) with aphasia as a result of left hemisphere CVA (10 ischemic, 5 hemorrhagic) that had all occurred at least 12 months prior to the study. All participants underwent the Test Barcelona (Guardia, et al. 1997; Peña–Casanova et al., 1997), a Spanish neuropsychological assessment which is similar to the Boston Diagnostic Aphasia Examination (2001). This assessment provided a percentile score for each participant, aphasia classification and also gave a measure of visual acuity. None of the aphasia

participants had problems of visual acuity or agnosia. Hearing was not tested formally. No participant showed clinical signs of hearing loss and none wore hearing aids.

Table 2 provides more detailed information on the participants with aphasia and includes their age and years of schooling, their CVA etiology, time post onset, aphasia percentile on the Test Barcelona and aphasia type.

TABLE 2 ABOUT HERE

Fifteen healthy volunteers were matched pair-wise on gender, age, years of education and laterality with the aphasia participant group. The healthy reference group provided the control data for naming the 200 pictures in the therapy program (CARP-2). The Spanish version of the Mini-Mental State Examination (MEC; Lobo, Ezquerra, Gómez-Burgada, Sala, Seva, & Diaz, 1979) was carried out on all participants. This assessment was used to ensure that the pair-wise matching was correct and that none of the non-aphasic participants had any cognitive deficits.

Table 3 shows the demographic data for the two groups (participants with aphasia and their matched controls).

TABLE 3 ABOUT HERE

Procedure

CARP-2 is a modification of CARP-1 (Adrian et al., 2003) and provides computer-assisted treatment by cueing and repetition training tasks. Full details of the original program and methods are set out in Adrian et al. (2003). An outline of the main differences between CARP 1 and CARP-2 is provided here:

a) An increase in the number of pictures from 60 pictures (40 objects and 20 actions) to 200 pictures (175 objects and 25 actions). A full list is available in the Appendix.

b) An increase in the number of semantic categories from 5 in CARP-1 to 8 CARP-2.

c) An increase in the number of cues provided from 4 in CARP-1 to 6 in CARP-2.

d) In CARP-1, the participant named from the picture only. In CARP-2 participants used three different tasks: naming the picture, naming the picture in the presence of an unrelated distracter and naming the picture in the presence of a semantically (or visually) related distracter.

e) In CARP-1 the participant carried out the training, once a week, for 12 sessions over 3 months. In CARP-2, treatment took place twice a week for 30 sessions (over 4 months), thus increasing the intensity but shortening the time taken.

f) In CARP-1, the participant chose 2 categories per session until she had worked on all 5 categories such that she saw either 10 or 20 items at any one time. In CARP-2, 20 items per session were set out in order by the program and included 5 items from each category.

CARP2 *features and tasks*

TABLE 4 ABOUT HERE

FIGURE 1 ABOUT HERE

Table 4 outlines the treatment procedure for the study. CARP-2 employed 200 items in the form of photographs of 175 objects and 25 actions in random order. It recorded each individual's results after each session providing summary feedback when appropriate. Figure 1 shows the therapist and participant at the beginning of a CARP-2 session (photo upper left). Stimuli and different tasks were presented on a large color screen (15 inches) controlled by a portable PC.

Three different types of task were used:

1. Naming from picture only (see example in Figure 1, upper right). The participant was instructed to name the picture which remained on the screen for 25 sec. If the participant could not name the image, they were provided with the following hierarchical cue sequence: semantic, phonological, mixed, cloze and written cues. These were the same as in CARP-1. However in CARP-2, the cloze cues were separated out into a separate category. As the hierarchy proceeded, the participant was given longer to respond with a maximum response latency of 25 seconds.

The reaction time of the participant was recorded manually by the therapist. Feedback on accuracy was immediately provided by CARP-2 (e.g., an applause sound when the response was correct or a bleep noise when it was incorrect or no response was made). At the end of each item, the participant heard the complete word and repeated it 4 times, with the picture and the written word on the on the screen.

2. Naming with unrelated distracter (see example in Figure 1, bottom-left). The participant heard a semantic cue and then had to choose the target item from two pictures where one was unrelated. For example, the participant heard the following cue: [¿medio de comunicación que sirve para hablar a distancia es el___?] 'What would you use to communicate over a long distance?' A _____?, The participant then selected the 'telephone' [teléfono] and ignored the 'spectacles' [gafas].

3. Naming with either a semantic or visual distracter (see example in Figure 1, bottom-right). In this task the participant again heard a semantic cue but this time the distracter was either semantically or visually related to the target. For example, the participant heard the following cue [¿parte del cuerpo que se encuentra en la cara, es el __?] 'What is a part of the body found on the face? It's an _? , the participant then selected the 'eye' [ojo] and ignored the 'eyeliner' [rímel]

Statistics

Differences between aphasic participants and healthy paired controls were assessed using an ANOVA. The Wilcoxon match pairs test was used to analyze the group results for the

participants with aphasia. The McNemar (an adapted Chi Square test for repeated measures) was used to assess individual change in the participants' performance pre and post therapy. Any aphasic performance within 2 St. Dev of the control mean was be deemed to be recovered to within normal limits.

RESULTS

The results of the naming therapy will be provided, showing the pre-treated scores of the participants with aphasia and their mean, followed by the post treatment measures and their mean.

Pre-treatment results:

At baseline, out of a possible 200 items, the group of participants with aphasia correctly named a mean of 70.67 (St Dev 44.50) with a range from 8 to 149. The mean correct responses in the control group was 194.27 (St Dev = 3.53) and a range of 184-198. The inter-groups difference is significant: $F(1, 28) = 112.94$, $p < .001$).

Post-treatment results

INSERT TABLE 5 ABOUT HERE

Table 5 shows the individual scores of the healthy matched controls and the participants before treatment and the results for the participants with aphasia after treatment. The McNemar values are also shown to indicate where there was a significant difference between pre and post therapy for the participants with aphasia. After treatment, out of a possible 200 items, the group of participants with aphasia correctly named a mean of 123.20 (St Dev 43.59) with a range from 56 to 187. Despite the considerable improvement in naming skills of the group with aphasia

following therapy (Wilcoxon matched pairs test, $z = 3.38$, 1 tailed $p < 0.001$), their skills remained significantly different to the healthy matched controls [$F(1, 28) = 13.36$, $p < .001$].

Individual variation

Figure 3 shows the responses of the 15 participants, ordered by severity of naming at baseline of the 200 items. It shows each individual before and after therapy (with their health matched controls in grey). The Figure highlights two aspects of the learning, firstly, that all participants learned (see McNemar results in Table 5) but to varying degrees linked to their initial anomia severity and secondly two individuals (NAS and GLM) appeared to approach healthy matched controls. However, both their scores fell just below 2 St Devs of the control mean.

FIGURE 2 ABOUT HERE

Control measures

INSERT FIGURE 3 ABOUT HERE

Figure 3 shows the group mean before and after therapy on the control measures (Raven's Colored Progressive Matrices (RCPM) and PALPA naming: EPLA 51 & 52) and their naming of the 200 therapy items in CARP-2. As predicted, there was significant improvement in naming performance on both the CARP items and the naming tests but no change occurred on the cognitive test.

Carry over of naming from one context to another

This study did not set out to specifically examine whether the gains made in therapy carried over to other exemplars or other contexts. However, because part of the background testing included two naming tests which were administered both before and after the therapy, it was possible to see whether there was any overlap in items between those in the naming tests and

those in the therapy battery. There were a total of 34 items in common (carry over set) between the therapy and the background naming tests (marked in bold in the Appendix). Although the pictures shared a common name they were different exemplars of the items (all the therapy items were colored photos and all the naming tests were black and white drawings). Before therapy, participants correctly named 41.38% of these items (with a mean of 14.07) whereas after the therapy the percentage correct increased to 82.35% (mean 28.00). This difference was significant for all participants (McNemar, 1-tailed, $p < 0.01$).

Carry- over of anomia treatment to non-treated items

In the same way, this study did not set out to examine whether the computer treatment might have a carry-over effect to items which were not treated. Anomia therapy has generally been found to be item specific, matching the specific phonology to the semantic concept (see Nickels, 2002 and Laine and Martin, 2006 for summary of evidence). However, this computer program used a wide number of hierarchical semantic as well as phonological cues (multicues) and so it was unclear whether this assumption should also be made here. In order to find out whether there was any carry-over to naming of non-treated items, the same two naming tests which had been administered both before and after the therapy were examined but this time, those items which did not occur at all in the program were analyzed. There were 61 items in total and each participant's ability to name the item before and after the computer program was explored. Table 5 shows the raw scores and the McNemar, two-tailed, values comparing pre and post naming of these non-treated items.

INSERT TABLE 6 ABOUT HERE.

For 11 of the 15 participants, there was a significant improvement in their ability to name the non-treated items from the baseline naming tests. There were, however, 4 participants whose naming did not improve on these tests.

DISCUSSION

The main purpose of this study was to extend the use of the computer assisted program from a single case to a wider range of participants with aphasia to find out if the treatment was 'active' (Wertz & Katz, 2004). These authors proposed an adapted five-phase outcome model for research into the study of computer-based interventions in aphasia which would address some methodological questions and terminology. The first question asked by this outcome model was whether the therapy program was 'active' and they suggested that Phases 1 and 2 of their model addressed this level of analysis. The purpose of Phase 1 was to test the treatment hypothesis to be developed in later phases. The main objective was to show that the treatment (in this case, a computer-assisted program for anomia) was active in improving aphasia deficits. Phase 2 studies deepened the results of Phase 1 by specifying who was more likely to improve from the therapy, to reconsider the type and number of stimuli, to determine the optimal intensity and duration of the treatment, to establish the appropriate order of tasks and stimuli and to demonstrate validity and reliability of the therapy program (by detecting pre-post improvement). Single case or single group reports were deemed appropriate for this level of research.

The current study showed that the computer-assisted rehabilitation program under observation here (CARP-2) was 'active' in the sense that 15 participants with CVA and chronic aphasia improved their ability to name after they had received the therapy program. The study hypothesized that this improvement could be attributed to the use multiple cues, given in a strict hierarchical structure (Pedersen et al., 2001; Doesborgh et al., 2004). Howard (1998) and Nickels (1992) have suggested that an outcome whereby the person with aphasia has learned how to cue themselves, by whatever means, would provide a better chance of that person accessing the words they need in situations outside of the therapy environment. This effect had been found in Adrian et al. (2003). In the current study, the evidence for this was sparse. However, 11 of the 15 participants were able to name significantly more untreated items following the multicue therapy than they did prior to the treatment. This study could not differentiate whether this improvement arose because participants became better at self cueing

or whether the increased number of semantic cues provided better differentiation within the semantic system such that stronger semantic activation improved later lexical access for non-treated items. It also remained unclear what factors prevented this kind of carry over in the 4 participants who did not improve on non-treated items.

The study also found that the computer-assisted program (with its varied cues and tasks) resulted in significant improvements for participants with different types and severity of aphasia. This study has shown that, though everyone improved their naming, they did not all do so equally; aphasia severity did not necessarily map onto their learning potential (Figure 2). As well as specific improvement in naming the study items in the program, participants showed carry-over of naming to the same (but untreated stimuli) in other naming assessments (PALPA). However, there was no change in another area of cognition (RCPM). This measure acted as a control, in the sense that if the program was merely one of stimulation, other areas of cognition might be expected to improve also. However this was not the case here and so the study concluded that the specific improvements in naming could be attributed to the CARP-2 program. These results were also consistent with previous studies which show that providing practice led to positive outcomes for individuals or small groups, no matter how chronic their anomia difficulties (Adrian et al., 2003; Choe et al., 2007; Doesborgh et al., 2004; Laganaro et al., 2006; Fink et al., 2002).

Despite the success obtained via the CARP-2 program, some limitations to this method might be apparent. Firstly, this type of multicue stimulation therapy was based on an assumption that participants with aphasia had relatively intact cognitive abilities. Computer programs based on this assumption have presented many different stimuli without necessarily correcting erroneous responses (Choe et al., 2007). The current program CARP-2 (and most of the others; see Table 1) provided feedback as to whether the item was correct or incorrect but did not give detailed feedback as to exactly where the problem might have lain in naming. Recent studies in errorless learning and anomia have suggested that those people with aphasia with more impaired

cognitive skills might benefit from errorless learning (Fillingham et al., 2005, 2006; Conroy et al., 2009). This is a method whereby the participant is given the correct answer and is not allowed to make errors. Programs such as CARP -2 and Mosstalks (Fink et al., 2002) are all inherently errorful (with the exception of Jokel et al., 2007 whose program was with people with dementia). Thus, the main beneficiaries of computer based anomia therapy programs such as that presented here may be for participants who have cognitive skills good enough to cope with errors. A more detailed analysis of the cognitive strengths of all participants would be needed to evaluate this hypothesis.

Secondly, in this study the speech-language pathologist was present throughout the practice to direct the computer program for auditory and written cues, as well as to provide specific feedback on the responses. Having the computer practice dependent on another person may limit opportunities for practice by the participant. Although other studies such as Fink et al. (2002) and Ramsberger and Marie (2007) have provided evidence that computer programs can be self directed, more precise feedback may be of benefit to some participants and it is not clear from this study who might require this extra feedback and how much of a contribution this extra feedback was to their overall improvement.

Thirdly, so far, it is unclear whether this treatment for anomia can have a direct influence on general verbal communication. To answer this, future studies related to the generalization of the treatment effects to the spontaneous language of the participants would be needed.

In summary, CARP-2 has been shown to be active in the treatment of anomia for different types of aphasia profiles. It is not yet, however fully demonstrated that the treatment provided was efficacious, effective and efficient. Wertz and Katz (2004) suggested that the next stage of evidence for a treatment program was to gain a better understanding of the intervention. Specifically, that Phase 2 should specify who was more likely to improve from the therapy, to reconsider the type and number of stimuli, determine optimal intensity and duration of the

treatment and establish appropriate order of tasks and stimuli and demonstrate validity and reliability of the therapy program (by detecting pre-post improvement). This study has not been able to show who does *not* benefit from this type of intervention, nor whether all the stages in the treatment were delivered in an optimal order or indeed whether each stage was essential to the learning. Neither does this study address the question of optimal intensity or duration of therapy. However, there exists already some useful hints in the literature to support a number of the methods used here; for example, providing multiple cues to participants to aid learning and consolidation (Beeson et al., 1995; Pedersen et al, 2001; Doesborgh et al., 2004), increasing semantic fields (Boyle, 2004; Kiran & Johnson, 2008), providing large number of items to learn (Laganaro et al., 2006; Snell et al., 2010), intensity of treatment (Basso, 2005) and using a strict hierarchical structure (Doesborgh et al., 2004). In future, CARP-2 will need to demonstrate efficacy (Wertz & Katz's Phase III) using longitudinal studies, which incorporate larger samples of participants randomly assigned to treatment groups. The collaboration of several centers would be required to advance in the reliability and validity of these kinds of tools in clinical practice.

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