New word learning in people with aphasia

Helen Kelly – University of Stirling, Scotland, UK
Linda Armstrong – Perth Royal Infirmary, Scotland, UK

Corresponding author – Dr Helen Kelly, *Speech and Hearing Sciences,School of Clinical Therapies, Brookfield Health Sciences Complex, University College Cork, College Road, Cork, T12 EK59 Republic of Ireland* - *helen.kelly@ucc.ie*

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Abstract

Background: The theory of speech and language therapy intervention for people with aphasia is still under-articulated, and some people with aphasia respond better to therapy than others. The reasons for individual variation in response to therapy have not yet been fully established but may partially reflect a person with aphasia's ability to utilise a range of cerebral mechanisms, such as re-accessing damaged neural pathways and establishing new ones. Most current therapies aim to help the person with aphasia access their previously available language abilities. New learning may offer an alternative therapy approach. However, there is little evidence to date on the effect of aphasia on a person's capability to learn new linguistic information. Aim: To explore the new vocabulary learning potential of people with aphasia.

Methods & Procedures: Twelve participants, under the age of 65 years and with a range of aphasia severity and personal backgrounds, were taught 20 novel words over four consecutive days. Their learning of this new vocabulary was measured via a range of single-word processing tasks based on the cognitive neuropsychological model. Ten participants repeated the tasks a few days later to establish whether the new vocabulary had been retained in long-term memory.

Outcomes & Results: All of the participants demonstrated some ability to learn the new vocabulary (both novel word forms and novel word meanings), with scores ranging from 15% to 99% on the various assessments. At the follow-up session, the ten participants retained between 49% and 83% of their previous scores.

Conclusions: This study has important implications for aphasia rehabilitation as it has shown that people with aphasia have the potential to learn new linguistic material, even in the presence of severe language impairments. This capacity could be exploited in therapy. Previously known words could be taught as new. Pre-therapy assessment of the person with aphasia's learning capacity and style would promote individually-tailored learning experiences and so, potentially, more effective therapy and better clinical outcomes.

Current Inadequacies in Understanding Aphasia Therapy

The current working practice of speech and language therapists (SLTs) starts with the assessment of an individual's particular manifestation of aphasia (Byng & Black, 1995). The data are then interpreted in terms of models of normal language processing, thus enabling hypotheses to be made about the specific nature of the person's aphasia, thereby guiding them to the area requiring rehabilitation. The rehabilitative process continues with the development of language therapy programmes in order to provide structured experience-dependent learning that facilitates language recovery. However, although the language impairment can be identified, Howard and Hatfield (1987) assert that this information does not determine which precise therapy programme is the most appropriate to target a particular area. Furthermore, Ferguson (1999) discusses models of aphasia therapy that were identified by Horner, Loverso, and Rothi (1994) and asserts that their specification does not explain how the therapy process targets impaired language functioning and achieves its outcomes.

As information-processing models prove useful in identifying targets for therapy, so a model of rehabilitation would similarly prove invaluable in determining the nature of therapy to use for a given impairment. To date however there is not a model or theoretical account that explains the dynamic therapist–patient interaction (Horton & Byng, 2000), what therapy is, or the process involved in rehabilitating the damaged language component(s). In order to develop this theoretical account and model of rehabilitation, additional questions must be addressed to determine how therapy works and to clarify what therapy is aiming to achieve (Byng, 1993) which in turn may help to define exactly what therapy is (Basso, 1989). SLTs in the UK have begun to address what therapy is aiming to achieve through making the decision making process of rehabilitation more explicit, overtly stating the aims (e.g., rehabilitative, curative) and goals of therapy, specifying tasks chosen to assess and treat, and the provision of evidence of therapy outcome (Malcomess, 2001; McCarthy, Lacey, & Malcomess, 2001). However the process that guides the judgement of the SLT in choosing the actual form of the therapy is still not explicitly addressed. It is not yet possible to discern which approaches or tasks will be successful in rehabilitating which particular aspects of aphasia (Best & Nickels, 2000). Additionally, it is not currently understood why some people with apparently similar characteristics of aphasia do not always gain equal restitution of language function (Best & Nickels, 2000). In order to fully investigate the process of recovery from aphasia any theory of rehabilitation would have to address the neurophysiological level of the recovery process (Gordon, 1999).

Potential Use of Learning Theories and Approaches?

Some prominent theories of or approaches to learning could be applied to aphasia rehabilitation as they incorporate conditions that are necessary for shaping adaptive behaviours while extinguishing maladaptive behaviours, thus instating or reinstating neural pathways (Ferguson, 1999). Howard (1999) argues that the use of theories of learning is not enough in itself but agrees that, in order to explain the theory of therapy, the process of aphasia rehabilitation may involve different kinds of learning at various stages of recovery. Furthermore, any theory of therapy would also have to address the question of how the process is effective in relation to the presentation of the language impairment.

One first step could be to establish if the rehabilitation of language involves facilitating the access of previously inaccessible memory traces; for example, already held vocabulary. This relates to Schuell, Jenkins, and Jiminez-Pabon's (1964) proposal that the aim of therapy is to maximise the efficiency of an impaired language system rather than teach new materials. Alternatively, it is possible that language therapy involves a process of new learning where new neuronal connections and pathways are being formed. Such information would indicate whether rehabilitation is a means of accessing previously known and now inaccessible information or memory traces due to post-stroke damage, a process that facilitates new learning, or both. If new learning were the underlying process of aphasia rehabilitation, it would be beneficial to look at theories of and approaches to learning as a possible means for explaining therapy.

However it has not yet been adequately proven that new learning occurs during the therapeutic process. In order to address this, a first step is to establish whether people with aphasia can demonstrate new learning despite language impairment. If adults with aphasia are unable to demonstrate the learning of new vocabulary, and naming performance improves, then it suggests that aphasia therapy facilitates the re-accessing of previously known information. Therefore, the tools and methods used in language therapy sessions should reflect this. If, however, adults with aphasia demonstrate that they can learn new vocabulary, then further examination of learning theories would perhaps reveal more about the therapeutic process, and therapy tools and methods could begin to incorporate novel methods to facilitate this new learning. So this study aimed to explore the potential of people with aphasia to learn new vocabulary (including both word forms and word meanings). The following discussion considers various learning approaches and techniques before identifying those that from the literature appear to have potential to optimise the word learning of people with aphasia.

Approaches to Enhance New Learning

A small number of studies have evaluated various learning techniques for adults acquiring new linguistic knowledge. Some employed the learning of unfamiliar words (e.g., Downes, Kalla, Davies, Flynn, & Mayes, 1997; Freed, Marshall, & Phillips, 1998). Others observed the learning of a foreign language (e.g., Lotto & de Groot, 1998; van Hell & Mahn, 1997) or used nonsense words or nonwords to observe vocabulary learning (e.g., Basso, Marangolo, Piras, & Galluzzi, 2001; de Groot & Keijzer, 2000). More recently a small number of studies have used brain imaging techniques to measure the learning of novel linguistic information (Cornelissen et al., 2004; Gronholm, Rinne, Vorobyev, & Laine, 2005).

Cueing Techniques

A much smaller number of studies have evaluated the ability of people with aphasia to learn new words. Similar to studies with healthy and memory-impaired adults, various techniques were employed to evaluate learning by people with post-stroke aphasia, from simply exposing participants to new vocabulary to devising complex strategies to aid the learning and retention of new linguistic information. Grossman and Carey (1987) report that in the 1970s several researchers attempted (but failed) to teach new words to people with aphasia. Their study aimed to evaluate the participants' knowledge of one unknown word (bice 5 shade of green). Participants were not told that they were learning a new word but were expected to learn ‘‘bice’’ through means of deduction and elimination from a selection of different coloured pens (one of which was the colour bice). Findings indicated that some participants achieved above chance on post-training assessments, which the authors suggest relates to individual presentations of aphasia. This method was similar to an ‘‘errorful’’ learning approach as participants were required to guess the new word, thus producing many errors. Basso et al.'s (2001) study of learning by the normal population (nonwords paired with pictures) suggested that while all three predetermined learning techniques (reading aloud, repetition, orthographic cue) were successful in aiding learning, an orthographic cue was found to be significantly more successful with regard to the number of presentations necessary to learn the words and the number of words remembered at follow-up. Basso et al. (2001) suggested that the treatment of word-finding impairment could perhaps use learning strategies that these normal controls used, so they evaluated the ability of two participants with aphasia to re-acquire commonly known vocabulary using these techniques. However the two studies were not comparable, in that the stimuli for the normal controls encompassed novel word associations (involving new learning) whereas the stimuli used for the aphasic participants were common words that they had difficulty retrieving due to word-finding difficulties. This study also involved elements of ‘‘errorful’’ learning where participant errors during training were not corrected. Marshall, Neuburger, and Phillips (1992) also evaluated a number of cueing (repetition, sentence completion, and self-cueing) and facilitation (word-to-symbol matching) techniques with people with mild-moderate aphasia. They found that participants could learn some of the new paired associations using both facilitation and cueing techniques. Cueing techniques were significantly more successful than facilitation.

Pre-exposure and Mnemonic Learning Techniques

The pre-exposure technique is another method thought to enhance learning performance and has been evaluated in paired face–name association learning studies (Downes et al., 1997; Kalla, Downes, & van den Broek, 2001). This technique involves presenting a visual representation of the stimuli prior to presenting the associated name—considered to be a significant factor in the encoding and storage/ consolidation of new vocabulary (Downes et al., 1997). Additionally, when the pre-exposure technique is combined with an imagery technique it produces significantly greater results than either technique alone for learning and recall. Imagery techniques involve capitalising on the high imageability of the associated words where participants receive (or create) a mental image for each face–name pair in an attempt to assign meaning to arbitrary labels; for example, imagining a picture of someone called Mr Fox as having a bushy tail in place of his nose (Downes et al., 1997). A further study also evaluated the pre-exposure technique and combined it with participants making judgements about each of the people in the photographs before being given the associated name (for example, if they looked honest, friendly etc.; Kalla et al., 2001). Their findings also indicated that the pre-exposure technique was an advantageous component to learning, because it provided a staggered learning process where the image (in this case a person’s face) was first established before the associative phonological component (their name) was superimposed. However, in order that this pre-exposure technique is beneficial to learning, the findings indicate that it must be used in conjunction with an efficient mnemonic strategy, which in this study was the evaluative judgements by participants (Kalla et al., 2001).

The use of a mnemonic technique in learning was further examined by studies investigating the learning of abstract symbols and words involving the creation of a phonological or visual (imagery) link between the word form and picture as a cue to aid learning (Downes et al., 1997; Freed, Marshall, & Nippold, 1995; Marshall, Freed, & Karow, 2001). Although there was great variability in the ability of participants to learn the new associations, those participants who used mnemonic techniques had significantly higher levels of naming accuracy and recall than those using other cueing methods such as phonological (Marshall et al., 2001), repetition, or sentence completion (Marshall et al., 1992). Additionally whether the participants created the cue themselves or it was devised by the researcher did not appear to affect learning performance (Freed et al., 1995).

Errorless Learning Approach

The training methods of many of the studies reported above required participants to guess the target response (similar to some clinical practice) or they were not provided feedback when they produced errors. This type of approach contrasts with another technique, an ‘‘errorless’’ learning approach, that has been proven to aid the learning and recall of new information in people with memory impairment. This paradigm asserts that people learn more successfully if they are prevented from making and reinforcing their own errors (Fillingham, Hodgson, Sage, & Lambon Ralph, 2003) and therefore incorrect memory traces are not laid down.

The application of errorless learning has been successfully used in several studies involving people with memory impairment, where training incorporating errorless learning led to a more effective acquisition of new skills. Tasks included teaching people with memory impairment face–name associations (Clare, Wilson, Breen, & Hodges, 1999; Evans et al., 2000), memorising word lists (Tailby & Haslam, 2003), learning word-processing skills (Hunkin, Squires, Aldrich, & Parkin, 1998), remembering a route around a room, programming an electronic organiser, and memorising a stepping-stone route (Evans et al., 2000). Kessels and de Haan (2003) performed a meta-analysis on the treatment effects of memory rehabilitation techniques using errorless learning techniques. They found a large and statistically significant effect size for errorless learning treatment and reported that errorless learning is an effective method for people with memory impairment. This technique is not considered equally successful for all types of tasks; for example, Evans et al. (2000) suggest that learning unfamiliar names may benefit from an errorless learning approach (using first letter cued recall and when learned, using an imagery technique) whereas other learning tasks such as learning a route or programming an electric organiser may not. In addition, errorless learning is more successful for people with severe memory impairments than those who are less severely impaired (Evans et al., 2000; Kessels & de Haan, 2003). However this effect was not found by Tailby and Haslam (2003) where participants with mild and moderate memory impairments performed significantly better than more severely impaired participants, although there was a greater difference in performance between errorful and errorless learning for the severe group than for the mild or moderate groups.

This approach has not yet been adequately researched in its purest form (i.e., elimination of errors during training) with people with word-finding impairments. However, some studies have successfully treated word-finding difficulties using another form of errorless learning—minimisation or reduction of errors during training (Fillingham et al., 2003). Fillingham et al. (2003) examined the word-finding rehabilitation literature in terms of whether the study employed errorful or errorless learning techniques. They identified an equal number of errorful and errorless methods (error reducing) demonstrating significant improvement following therapy. Two studies were identified that employed a pure errorless learning approach and only one of these was successful post-training and at follow-up. It was concluded that error-reducing techniques do have positive effects for patients with word-finding difficulties. However, there is very little evidence to judge whether errorless learning is significantly advantageous over errorful techniques. Further research in this area is therefore strongly recommended.

Identifying Optimum Learning Techniques

The above studies provide some evidence that people with aphasia have the potential for new learning, albeit to varying degrees; i.e., not all items were learned by successful participants and some participants were more successful at learning than others. Various learning techniques have been evaluated with healthy adults, memory-impaired people, and also people with aphasia to determine the optimum methods of acquiring new linguistic information. A number of factors identified in the literature are considered to influence learning. First, active participation while learning produces better memory retention than passive observation (Basso et al., 2001; Vakil, Hoffman, & Myzliek, 1998). The opportunity for rehearsal is also considered important in assisting the transfer of newly learned items from short-term to long-term memory (Marshall et al., 1992). Cognate words were more easily learned than non-cognates (de Groot & Keijzer, 2000; Lotto & de Groot, 1998). Additionally, the presumption that healthy adults could not be motivated to learn nonwords was dismissed (de Groot & Keijzer, 2000). Finally three techniques were identified from the literature as potential methods for optimising new learning—pre-exposure, mnemonic techniques (self-judgement, imagery), and errorless (error reduction) learning. The pre-exposure technique was found to be a significant factor involved in the acquisition and retention of new vocabulary, and when combined with mnemonic techniques it produced significant gains in the learning and recall of new words (Downes et al., 1997). However new word learning by a normal population in preliminary studies (McGrane, 2006) revealed that imagery techniques were not beneficial to all learners. Participants who reported using mnemonic strategies, such as imagery and mnemonic phrases, achieved greater learning performance for new vocabulary than those who reported using repetition and written copying to aid their learning—appearing to support the literature advocating imagery and other such mnemonic learning strategies. However in a second study when these same participants were advised to employ mnemonic techniques alone to learn a similar set of stimuli, only some participants improved their learning performance from the first study. Any improvement in learning performance was not significant, suggesting that the use of mnemonic strategies is suitable for some but not all new vocabulary learners. This could possibly explain performance variability between participants in the imagery studies discussed above. As different learning strategies are useful for different people it was decided to introduce a variety of learning strategies to the participants with aphasia in this study, where they could choose the one most suited to their particular learning style.

Although there is a paucity of research in the use of errorless learning, it has been successfully used in learning studies with memory-impaired participants (Clare et al., 1999; Evans et al., 2000; Hunkin et al., 1998: Kessels & de Haan, 2003) and, for people with word-finding impairments, appears to be as good as traditional trial and error studies (Fillingham et al., 2003). As this study is investigating new learning it was considered appropriate to use this error reduction and where possible error elimination approach during the training procedure, with the aim of reducing the creation of inaccurate memory traces and promoting correct responses.

A Methodological Issue

A major methodological issue surrounds the studies reported above when considering the learning of new vocabulary. While the studies investigated the ability of people with aphasia to learn new associations with already held information, none of these studies investigated the learning of new vocabulary where both the word forms and word meanings were novel. A number of the studies have employed (potentially) already held phonological representations; for example, surnames (Downes et al., 1997), dog breed names (Freed et al., 1998; Marshall et al., 2001), or potentially familiar words (Freed et al., 1995; Grossman & Carey, 1987; Marshall et al., 1992). Other studies used novel word forms (nonwords) with already held semantic representations—pictures of familiar objects (Basso et al., 2001; Lotto & de Groot, 1998; van Hell & Mahn, 1997). Therefore the question of whether the damaged adult linguistic system is capable of acquiring new vocabulary involving new word forms and word meaning/concepts still remains to be investigated—that is the focus of this study.

Aims and Objectives

The overall aim of this study was to explore the new vocabulary learning potential of people with aphasia, when both novel word forms and word meanings were presented. Its component objectives included, importantly, the development of an appropriate methodology (including devising the new vocabulary and compiling an assessment of learning), preliminary trials of this methodology with healthy participants, and a description of their learning techniques (McGrane, 2006). This paper describes the main study, which evaluated the potential of people with post-stroke aphasia to learn new vocabulary.

Method

Participants

The inclusion and exclusion criteria for participation in this investigation aimed to eliminate as many factors as possible that might impact negatively on the ability to learn the new vocabulary. In order to reduce possible age-related artefacts, participants were aged 65 years or younger. The potential of rehabilitation for the participant population was considered to be an important factor. Therefore any language disability presented by potential participants was as a result of stroke rather than a deteriorating condition. All participants had been diagnosed with aphasia by an SLT. The severity of aphasia was not specified, so as to provide evidence of the learning potential of people with a range of language difficulties. Linguistic profiles also differed since it is not yet known whether there is any relation between word-finding difficulties and the ability to learn new words in people with aphasia. In order to reduce extraneous influences on the ability to learn, participants who were not medically stable, or who had any history of mental illness, progressive illnesses, or illegal substance abuse were excluded. Visual and hearing acuity was required to be sufficient to enable participation in the training and assessment tasks. As these were in English, prospective participants whose first language was not English were excluded. A total of 14 participants were recruited, but 1 participant had severe visual impairments and was unable to participate in the screening assessments and another participant began the training but withdrew because of illness after two training sessions. Demographic information about the 12 participants who completed the study is given in Table1.

Table 1 around here

Procedure – Pre-Training

Screening assessments, a novel vocabulary set, a learning procedure, and a learning assessment were finalised following a series of pilot studies. Screening assessments were administered prior to the training sessions to establish the cognitive and linguistic abilities of each participant at the time of the investigation, their overall emotional state, and also their vision and hearing adequacy for participation. In order to highlight various methods of learning new information, while allowing participants to choose their own preferred method, common methods of learning were discussed during this initial session and a leaflet depicting each method (in written and picture format) was given to each participant (McGrane, 2006). The Hospital Anxiety and Depression scale (HADs; Zigmond & Snaith, 1983) was completed with each participant. The cognitive abilities of each participant were screened using the Cognitive Linguistic Quick Test (CLQT) (Helm-Estabrooks, 2001) and their non-linguistic learning ability assessment was based on a learning task evaluated by Evans et al. (2000). This ‘‘stepping-stone route’’ task required participants to learn a specified set of nine moves to successfully complete the route, and involved immediate and delayed recall.

A language screening test using single words, compiled by the first author, was administered to each participant. The items included extracts from published assessments such as the PALPA (Kay, Lesser, & Coltheart, 1992) and picture stimuli from the literature (Snodgrass & Vanderwart, 1980). The assessment included repetition of 8 words and 8 nonwords (PALPA; Kay et al., 1992), auditory lexical decision of those 16 items, naming of 12 pictures from Snodgrass and Vanderwart (1980) (6 with a high familiarity rating and 6 with a low familiarity rating), reading aloud 8 words and 8 nonwords (the same items as used in repetition task above), visual lexical decision of these 16 items, categorisation tasks involving (a) 15 shapes (5 circles, 5 squares, and 5 triangles); (b) 15 colour pictures (Boardmaker Picture Index, 1996), 5 each of two closely related semantic categories (fruit and vegetables), and 5 from an unrelated semantic category (clothes); and (c) the typed labels of the 15 pictures from (b) above and written spelling of 6 words and 6 nonwords to dictation (PALPA; Kay et al., 1992). The psycholinguistic profile of each participant in relation to these assessments is presented in Table2.

Table 2 around here

Procedure – Training

The one-to-one training sessions operated once a day for 4 consecutive days, with each session lasting approximately 1 hour. Each of the training sessions incorporated the establishment of a pre-training baseline, and introduction to, familiarisation with, training in, and assessment of the novel words. During the training process the researcher adopted a ‘‘trainer/teacher’’ role and the participants the role of ‘‘learner/ student’’. The training phase, which was structured to promote active learning, was led by the researcher to ensure that all participants had the same learning opportunities. Prior to each training session, participants performed a listening and reading baseline recognition task. This consisted of 5 familiar creatures (e.g., cat, goat), 5 novel word forms to be trained (Table3), and 5 control nonwords (e.g., pisture, otion). As the creatures to be trained were novel it was expected that the scores for each task would be zero recognition for these novel items. These baseline tasks allowed participants to display their knowledge of already familiar creatures and their ability to recognise nonwords, which participants indicated through verbalising yes/no, gesture, or pointing to a printed yes/no card. It also provided practice of two lexical decision assessments that they would undertake following the training period, thereby reducing test artefact effects. As the only requirement of this task was to indicate if the participants had previously heard or seen the words, it was not anticipated that this would affect the ‘‘errorless’’ learning approach during the training phase.

The first part of the training process incorporated a pre-exposure judgement task that would establish the semantic basis for further staggered learning (Downes et al., 1997; Kalla et al., 2001). Participants were shown pictorial images of the new words and were asked to make judgements about them. At this stage participants had not been given any additional information about each ‘‘creature’’. The training then continued using a staggered learning approach where each creature’s image, and phonological and semantic information was individually presented (McGrane, 2006). Participants were allocated independent learning time (ILT) (maximum of 30 minutes) to learn as many details as they could about each creature (i.e., name, skill, habitat, and food), to promote rehearsal and consolidate learning. The researcher withdrew from the room at this stage leaving participants to manage their learning in whatever manner they chose (although participants could ask for further direction). In order to reduce errorful learning, reduce assessment task artefact, and help to structure the learning period, a number of tasks were made available for participants to use (if they wished) to aid their learning of the stimuli during this time. The ILT incorporated an errorless learning approach to facilitate the learning of the new vocabulary; that is, as participants could listen to the stimuli through audio recordings without being required to respond, copy the new words (written), and immediately check their responses to the various tasks, it reduced errorful memory traces being created. At the end of the ILT all stimuli were removed from participants.

Table 3 around here

Table 4 around here

Assessments were administered following the ILT to establish what participants had learned about the 5 words during each session. As it would be important to facilitate the demonstration of learning by those participants who were unable to verbalise the new words, a range of assessments was administered both in spoken and written format (Table4). At the end of the fourth training session participants were given the opportunity to rehearse all 20 words both in written and auditory modes in order to reduce recency effects during delayed recall assessments. A total of 10 participants (P3 and C1–C9) agreed to a delayed recall assessment 3 to 5 days following the final training session.

Results

The main research question of this investigation was whether adults with aphasia could learn new vocabulary despite having language impairments as a result of their stroke. The degree of ability to learn the new vocabulary was assessed by totalling each participant's raw scores for the assessment tasks (Table4). The immediate recall totals for each participant are presented in Table5. For convenience, participants are numbered according to immediate recall score. There was a wide range of learning ability, from the lowest percentage correct of 15% to the highest percentage correct of 99%. As the more ability a participant had for spoken and/or written communication, the better score they could potentially achieve, assessment tasks that did not require spoken and written responses were subtracted from the total raw scores given in Table5 and a slightly different picture emerged. Table6 presents the ranking of participants using these amended raw scores and percentages. Although individual rankings of participants changed, the original top three participants (C1, P3, and C2) remained the top three scorers and the lowest-scoring participants (C9, C10, and C11) remained the lowest scoring.

Table 5 around here

Table 6 around here

The delayed recall totals for each participant are presented in Table7. Participants are listed according to their performance in descending order. As with the immediate recall scores there was wide variation in delayed recall performance, with the percentage correct ranging from 17.5% to 82%. The percentage of items recalled from immediate recall assessments was compared with the information recalled from the delayed recall assessments. The percentage of retained learning ranged from 49% to 83%. This indicated that much of the new learning was retained. The ranking position of participants in the immediate recall was not the same for delayed recall.

Table 7 around here

Learning Performance in Relation to ILT

The amount of time used to rehearse and consolidate new learning by participants during their ILT and the learning strategies they employed were noted to examine if particular strategies enhanced their learning scores (Table8). Three participants, C9, C10, and C11, were unable to structure their ILT and required the researcher to offer them the opportunity to complete the same tasks as other participants. When the learning performance of the nine participants who structured their own learning is examined, it is noted that more time spent rehearsing and consolidating new learning resulted in higher learning scores, i.e., more new learning occurred. The various learning strategies used by those participants who were able to structure their ILT (Table8) indicate that each person had their own particular style of learning.

Table 8 around here

Learning Performance in relation to Individual Stimuli

Characteristics of the new words were examined to ascertain if any words were particularly easy or indeed difficult to learn (for example, bi-syllable versus trisyllable words) and also to investigate if participants demonstrated primacy or recency effects across sessions. The number of times the new words were recalled in both immediate and delayed recall assessments is presented in Table9 in descending order. The new word recalled most successfully during immediate recall assessments was ‘‘FUTARG’’—the first word presented in session 1 (recalled 134 times throughout various assessment tasks). The second most frequently recalled new word was ‘‘CURVOL’’—session 4 (recalled 128 times). The two words that appeared most difficult to learn were ‘‘SILVARK’’—session 3 (recalled 108 times) and ‘‘JUNFLIZ’’—session 2 (recalled 106.5 times). The delayed recall assessments revealed that participants were best able to retain ZOODOP and SILVARK in long-term memory (both recalled 86 times). Participants found ‘‘LUNDRIL’’—session 2 (recalled 65 times) and ‘‘HAMEKIN’’—session 3 (recalled 60.5 times) the most difficult words to retain. The two words most successfully learned (immediate recall) were from sessions 1 and 4, suggesting perhaps a recency and primacy effect. However, as Table8 indicates, the words most easily recalled and the ones that appeared most difficult to recall were spread throughout the four sessions.

Of the 20 words, 4 were tri-syllabic and the other 16 were bi-syllabic. The third most successfully learned word was the tri-syllabic word FEETOKEL (recalled 126 times), which suggests that tri-syllabic words were not more difficult to learn than bisyllabic words. POPKINEL (positioned 13th) was recalled 116 times, HAMEKIN (15th) was recalled 114 times, and PONCHINO (17th) was recalled 112 times. In delayed recall, however, POPKINEL and FEETOKEL were positioned 7th and 10th respectively with the other two words being more difficult to remember. Overall trisyllabic words did not appear to be learned any differently from the other words (see Table9). However, as there was a smaller number of tri-syllabic compared to bisyllabic words, further investigation with a similar number of each syllable structure would be more informative.

Table 9 around here

Learning Performance in relation to Learning Assessment Tasks

The various assessment tasks are listed in Table10 in descending order beginning with those tasks at which participants performed most successfully. Participants performed most successfully on the listening and reading recognition of the new words and syllable completion tasks, both for immediate and delayed assessments. The least successful performance involved spoken naming of the new word forms and one of the associative meanings (skills) for both immediate and delayed recall.

Table 10 around here

Discussion

This investigation has established that people with aphasia can learn new vocabulary despite residual language impairment. All 12 participants demonstrated some ability to learn the new vocabulary. Their performance on the assessment tasks varied from 15% to 99%. Even the low-scoring participants learned a number of different characteristics about particular words, confirming that learning had occurred. A total of 10 participants were reassessed 3–5 days following the final training session. Of some interest is that the two lowest-scoring participants declined. All 10 demonstrated some ability to retain the newly learned information in long-term memory—their scores ranged between 17.5% and 82%. The percentage of information recalled from delayed recall assessments was compared with immediate recall assessments—the percentage of information retained from the training sessions varied from 49% to 83%. There were no instances of participants recalling information about the new words in delayed recall that had not been recalled in immediate recall assessments. The pattern of wide variation in the performance of the participants with aphasia mirrored that of the performance by participants with no cognitive or language impairment in the preliminary studies (McGrane, 2006). There were also some qualitative similarities between the normal population and the aphasic population. Occasionally both population groups made semantic errors between the new words and the images; made phonemic errors; described skills when unable to think of target words (e.g., ‘‘to do with vision’’, for the skill of x-ray vision); and experienced between-session interference when the name (new word) or associative meaning (skill) for one new word was attributed to another. However, qualitative differences were also revealed in the data for the population with aphasia when compared with the normal population (McGrane, 2006). It was felt, therefore, that the variation in performance of people with aphasia could be attributed to more than merely normal variation. Participants with aphasia presented with diverse personal profiles, for example different ages, years in education, months post-stroke, cognitive and language functioning. It was speculated that these factors may have accounted for the variability in performance by participants with aphasia in the learning and retention of the new vocabulary and these are explored in another paper (Kelly & Armstrong, 2008).

Some work preliminary to this study, involving healthy people, also revealed that participants had preferred learning styles and they were not all readily able to change to another one (McGrane, 2006). Therefore instead of promoting a particular learning style, participants were given information explaining various learning techniques and were advised to use the one(s) they found most suitable during their independent learning time. In order to reduce errorful learning, reduce assessment task artefact, and help to structure the learning period, participants were given a number of tasks they could complete during this time. Qualitative data indicated that participants listened to the audio recording of the details about the new words; read over or practised the assessment tasks; wrote down details as they rehearsed them; rehearsed details aloud. However, the three participants with the lowest learning performance (C9, C10, and C11) were unable to structure their independent learning time and required direct guidance from the researcher, who gave them the opportunity to complete the same tasks as other participants. This suggests poor planning ability perhaps reflecting their cognitive impairments, in particular executive functioning. It was noted that participants who employed more independent learning time were also more educated, perhaps reflecting the knowledge of how to learn effectively. These same people were also employed in occupations of higher complexity than other participants, perhaps suggesting the usefulness of cognitive reserve in the learning process. It was not possible to quantify the benefit of the independent learning experience or the strategies used by participants to rehearse and consolidate their learning. However, the amount of time used by participants was recorded and measured against their learning score and was found to correlate (Kelly & Armstrong, 2008), therefore the longer participants spent consolidating the new vocabulary the more successful they were in learning and remembering the new words. Implications for language rehabilitation include the provision for adequate time for repetition and consolidation of therapeutic stimuli as well as ensuring that the correct representation and connection is being formed during this time, perhaps in the form of errorless learning.

An errorless learning approach was employed in the training procedure for this investigation. Errorless learning may be an appropriate approach to employ in the rehabilitation of language. As discussed earlier, this method has proved useful for many people particularly those with memory processing impairments. Fillingham, Sage, and Lambon Ralph (2005) highlight the paucity of research that employs errorless learning for the amelioration of aphasia, and stress the difficulty in designing therapy that would result in the person with aphasia only ever producing correct responses. Recent findings suggest that while participants strongly preferred errorless learning techniques, as they are less frustrating and more rewarding than errorful techniques, errorless learning produced equivalent results to errorful learning in the rehabilitation of anomia (Fillingham et al., 2003, 2005). However, as there appears to be a paucity of research in this area and all participants in the above investigations did not learn the new words to the same extent, further exploration is warranted. It was observed that participants tended to consistently use their same chosen learning techniques across training sessions. Therefore perhaps participants’ different learning styles may account for some of the variation in participant outcome. Perhaps further language therapy investigations should take this factor into account where people may gain further functional improvements using methods more suited to their own individual learning styles.

Therefore although the same stimuli might be used in rehabilitation, differing approaches to learning may provide an explanation for the differences found in the recovery of aphasia. This information could be fundamental to the success of language rehabilitation in that problems in facilitating restitution of language may not be caused by the particular tasks employed but rather the manner in which they are presented. Perhaps discovering the optimum learning strategy for each individual before embarking on the therapeutic process would identify the best methods and processes to use during their rehabilitation process. The use of learning concepts could revolutionise aphasia rehabilitation and promote the identification and establishment of optimum methods of learning to facilitate the highest potential restitution of language and thereby the reduction of any harmful or redundant therapy tools or methods, having a corresponding effect on the reduction of maladaptive neuronal connections. The incorporation of learning theory in future investigations could examine the constraining factors of new learning by people with aphasia.

Participants presented with different stroke histories and a wide range of severity of cognitive, emotional, and language functions, as well as differing abilities to learn the new vocabulary. While it is acknowledged that this sample is not large enough to generalise the findings to the general aphasic population, it was sufficient in number to demonstrate that adults with post-stroke aphasia can learn new vocabulary despite residual language impairments. Further investigations should involve larger numbers of participants with a range of impairments to enable the use of more powerful quantitative and richer, more informative qualitative statistics.

The stimuli developed were not only unique for this investigation but also represent the first set of novel word forms and word meanings that has been reported to evaluate the capacity of adults with aphasia to learn new vocabulary. This had been a methodological issue with previous learning investigations with this population. The training methodology was based on optimum methods of learning from published research. Previous studies used different methods of evaluating learning, with some of them employing spoken and/or written responses alone. However this investigation employed a range of assessments to facilitate the demonstration of learning particularly by those participants unable to respond in spoken and/or written formats. The results suggest that the assessment tasks used to evaluate new vocabulary learning were sensitive enough not to disadvantage non-verbal participants.

Suggestions for Future Research

A large-scale replication of this research would increase the dataset and provide additional information regarding the learning abilities of people with aphasia. Variability in individual participant data in this investigation supports the requirement for single case study reporting; however, a larger sample may identify aspects of new learning that could inform the general aphasic population rather than reflecting individual idiosyncrasies. The provision of more detailed biological and neurological information with a larger population would also allow for analyses of the biological limitations to learning new vocabulary and related cortical plasticity. Additionally, the impact of type of stroke (i.e., infarct versus haemorrhage) could be analysed in relation to new linguistic learning. Brain-imaging techniques have been used to observe brain plasticity in response to rehabilitation of aphasia (Cornelissen et al., 2003; Meinzer et al., 2004; Weiller et al., 1995). The use of brain-imaging techniques in new learning studies would not only determine the location and severity of neurological damage but also identify the extent and location of cortical reorganisation following training, thus further contributing to knowledge of the abilities and mechanisms involved in the damaged brain learning new vocabulary.

In this investigation participants were trained on five words per day for 4 days and each day had a maximum of 30minutes to consolidate this learning. Participants had different learning styles and pre-morbid experience in learning skills. The lower scoring participants also had less education and subsequently may have been less skilled in learning strategies and techniques. Any further investigation should ensure that all participants were given some time pre-training to explore their particular learning techniques. In addition to learning techniques, participants may have different learning rates, i.e., some people can memorise information more quickly than others. It would be useful to ascertain if intensive learning of the vocabulary would increase the performance of those low-scoring participants, where they would learn fewer words over the same period of time (4 days) or have a longer period of time to learn the same set of items. This information would further inform therapy as to the different ways that patients interact with the rehabilitation process, and highlight methods of ensuring that each individual is given the opportunity for optimal restitution of language before resorting to alternative communication methods. The impact of cognitive impairments on the acquisition of new vocabulary has not been discussed here, but more in-depth assessments that are sensitive for people with aphasia are required for future research.

This investigation employed new single words in the form of common nouns. Further investigation would extend the examination of the ability to learn new vocabulary in isolation to analysing how these words would be incorporated into connected speech and the factors that may impact on their use. Additionally, new vocabulary in the form of verbs could be examined and compared to the ability to learn and use common nouns. This would be of particular interest for those people with acquired grammatical impairments.

Conclusion

At present there is no complete theory of language rehabilitation and it is not known if aphasia rehabilitation could incorporate new learning or if rehabilitation involves only facilitating the person's access to previously known but now inaccessible memory traces. To begin to address this, people with post-stroke aphasia must be able to demonstrate that they can learn new language-related material. Prior to this investigation this was not known. While previous studies had demonstrated that people with aphasia have the general ability to learn, these studies involved paired stimuli with a familiar and matched novel component. The main aim of this investigation was to bridge this gap in current knowledge by an examination of whether people with aphasia can simultaneously learn new word forms and word meanings.

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