Optimising rehabilitation outcomes for aphasia following stroke through new learning

Helen McGrane
Nursing, Midwifery and Allied Health Professions Research Unit, University of Stirling

Background

The aim of aphasia rehabilitation is to return a person to their highest communicative potential. However not everyone with aphasia recovers to the same extent following a stroke and many people retain residual language impairments to varying degrees of severity. Even where people who appear to have the same impairments receive the same therapeutic intervention they do not always achieve the same outcomes[1]. While there are theories and models of language impairment such as the cognitive neuropsychological approach, currently there is no model or theory of rehabilitation that explains what therapy is or describes the process(es) involved in the restoration of the damaged language system[2]. Such a model or theoretical account would identify the process of therapeutic rehabilitation and highlight any constraints to the restitution of language impairment. Additionally, it would identify those most likely to benefit from language rehabilitation, thereby allowing more targeted allocation of limited resources.

The development of a theory of rehabilitation would be a considerable undertaking. A first step however would be to ascertain if therapeutic interventions facilitate the accessing of previously known information rendered inaccessible due to the impact of the stroke. Cortical plasticity occurs during language rehabilitation and also during the learning process[3,4]. Therefore, the rehabilitation of aphasia could involve the process of new learning, resulting in the creation of new neuronal connections for vocabulary newly acquired (or re-acquired) during the therapeutic process. A small number of studies have investigated the potential of domain-specific learning by people with aphasia where the stimuli employed by these studies involved already familiar word forms or meanings[5,6]. While these studies provide evidence that people with aphasia have the potential to learn, no study had employed unfamiliar word forms paired with unfamiliar word meanings i.e. new vocabulary.

This investigation aimed to explore the ability of adults to learn new vocabulary despite the presence of post-stroke aphasia. If they were unable to demonstrate the learning of new vocabulary then it would suggest that aphasia therapy facilitates the re-accessing of previously known information. If however, adults with aphasia demonstrate that they could learn new vocabulary then language therapy tools and methods could incorporate novel methods to facilitate this new learning (e.g. can we teach the old words as new words encouraging new pathways to be laid down?).

In order to ensure that each participant had no previous memory trace of either the word form or meaning novel vocabulary was created. There is some indication that verbs and nouns are processed differently[7] with nouns more easily retrieved than verbs [8,9]. Additionally, common nouns and proper nouns appear to operate differently[10] with proper nouns acting more like labels associated with a referent without semantic meaning[11]. New words are best acquired by forming associations with already held words or concepts making them more meaningful[12]. Therefore the new vocabulary were designed to operate as nouns and given associations with already familiar words. Three techniques were identified as optimal learning techniques – pre-exposure technique[13,14], imagery techniques, in particular self-judgement tasks (providing a staggered learning effect) [14] and errorless learning[15]. As

the investigation evaluated the learning of vocabulary a single word processing model based on the cognitive neuropsychological approach was considered suitable. This model is commonly used by clinicians and researchers in identifying impairments of single word processing ability of people with aphasia. The use of this model enabled the investigator to capture not only participants' spoken and/or written output but also their recognition of the stimuli and any knowledge of the word forms or meanings that they may acquire.

Method

Participants

The inclusion criteria for participation in this investigation were chosen in order to eliminate as many contaminating factors as possible. In order to reduce possible age-related artefacts participants were aged 65 years or younger. The severity and type of aphasia was not specified in order to observe performance from people with a wide variety of language difficulties. In order to reduce extraneous influences on the ability to learn, participants did not have a history of mental illness, progressive illnesses or illegal substance abuse. Recruitment of participants was mainly through NHS trusts, a local college (educating people with disabilities) and the Chest, Heart and Stroke Association. Six men and six women were recruited, age range 33;11-64;04 years. Participants presented with a wide range of years in education (9-21.5 years), level of occupation (homemaker to pharmacist), severity of aphasia and cognitive abilities (mild to severe) and were at different stages of recovery from their stroke (5-146 months).

Procedure

Twenty novel words (Appendix A) were taught to the 12 participants over four consecutive days (approximately one hour each session). The training procedure involved obtaining baseline measures; introduction and familiarisation with the new stimuli (pre-exposure judgment task); training of the stimuli (phonological and semantic information) and consolidation of learning (independent learning time where participants had various options to rehearse their learning, for example, listen to audio cassette, look at paper versions of the stimuli or practice various tasks).

Results

The immediate and delayed recall of the new vocabulary was investigated using a range of assessments to facilitate the capture of new learning. All 12 participants partook in the four training and immediate recall sessions. Due to the nature of aphasia some participants were unable to demonstrate their learning in spoken and /or written form. However, the various assessments based on the cognitive neuropsychological approach facilitated the demonstration of this learning in ways other than spoken or written recall and provided evidence that every participant learned some of the new vocabulary. Learning abilities ranged from 15% to 99% for immediate recall tasks. These assessments were repeated three to five days following the final training session to measure the extent of information that was retained in long-term memory (delayed recall). Ten participants partook in delayed recall assessments and performance indicated that retention of original information learned ranged from 49% to 83%. Two of the 12 case studies will now be presented.

Case Study 1

Case study 1 (C1) was male aged 33;11 and was 39 months post-stroke (left middle cerebral infarct). Screening assessments indicated 'normal' anxiety and depression levels (HADs[16]) and attention and executive function were within normal limits with moderately impaired memory (CLQT)[17]. C1 presented with severe language difficulties with all spoken output (even at single word level) i.e. repetition, reading aloud, spoken naming and spelling non-words. Although he found verbal communication frustrating C1 used writing and drawing to effectively communicate his message at single word level, on most occasions. However he was unable to communicate beyond the single word which was further exacerbated by severe verbal dyspraxia.

C1 had significant difficulty recalling the new words in spoken form due to his marked dyspraxia but used non-verbal methods to communicate his knowledge of the new vocabulary. Despite severe language impairment he demonstrated the ability to learn new vocabulary by recalling 89% of the new information for immediate recall (IR) assessment tasks (see Table 1). Additionally despite being unable to spell any non-words at baseline he could write all 20 new words with no spelling errors strongly suggesting that these representations were now stored as real words in his lexicon. C1 demonstrated long-term retention of these new words by recalling 66% information in delayed recall (DR) tasks (see Table 1).

Case study 2

Case study 2 (C2) was female aged 57;07 and was 114 months post-stroke (left fronto-parietal and right internal capsule infarct). The HADs revealed 'abnormal' anxiety and 'borderline abnormal' depression levels. The CLQT[30] indicated attention and executive function were moderately impaired with severe memory impairment. C2 presented with severe language difficulties with all spoken output (even at single word level) i.e. repetition and reading of words, repetition and reading of non-words, spoken naming and spelling of words and non-words. C2 could not use writing or drawing to communicate therefore found communication frustrating. During the consolidation and rehearsal time C2 was unable to choose tasks or organise her learning. To ensure she had the same rehearsal opportunities as other participants guidance was provided for each task.

C2 was unable to recall the new words in spoken or written form but demonstrated new learning using non-verbal methods, for example, word-picture and word-syllable matching. Despite severe communication impairment C2 demonstrated the ability to learn new vocabulary by recalling 24% of information for immediate recall and retaining 74% of this information at delayed recall assessment (see Table 1). Qualitative analysis of the data indicated that she had learned a number of different characteristics about particular words confirming that learning had occurred rather than as a result of purely random responses (i.e. by chance).

Table 1
Immediate (IR) and delayed (DR) recall performance on assessments for two cases
C1 and C2 (%age correct)

Assessments	**C1**		**C2**	
	IR %	**DR %**	**IR %**	**DR %**
Cold recall tasks				
Creature names (spoken)	**20**	**15**	**0**	**0**
Creature names (written)	**100**	**20**	**0**	**0**
Creature skills (spoken or written)	**90**	**0**	**0**	**0**
Creature habitat (spoken or written)	**100**	**60**	**20**	**25**
Creature food (spoken or written)	**100**	**60**	**80**	**35**
Lexical recognition tasks				
Recognition of new words alongside other words and non-words (spoken)	**90**	**100**	**0**	**0**
Recognition of new words alongside other words and non-words (written)	**100**	**100**	**0**	**0**
Word-Picture matching tasks (choice of five)				
Spoken new word with picture of creature	**100**	**95**	**15**	**35**
Written new word with picture of creature	**100**	**100**	**25**	**10**
Spoken skill with picture of creature	**100**	**45**	**35**	**25**
Written skill with picture of creature	**100**	**55**	**35**	**10**
Categorisation tasks (choice of five)				
Picture of creature	**100**	**50**	**45**	**30**
Written name of creatures	**95**	**55**	**25**	**35**
Other tasks				
Read new words aloud	**25**	**10**	**5**	**0**
Picture of creature with number of syllables of name (choice of three)	**100**	**80**	**50**	**55**
Completion of new word with final syllable (written) (choice of five)	**100**	**95**	**45**	**20**

Discussion

It has now been established that people with aphasia can learn new language representations in the form of new vocabulary despite residual language impairment. All 12 participants demonstrated some ability to learn the new vocabulary and performance varied from the highest recall score of 99% to the lowest of 15%. The findings, which strongly suggest that language rehabilitation could incorporate the process of new learning, have significant clinical relevance in terms of developing a theory of rehabilitation and to the procedures employed in speech and language therapy. If a theory of rehabilitation incorporated theories of learning then it would be important to identify any constraining factors impacting upon this new. Ten participants were reassessed 3-5 days following the final training session i.e. delayed recall. All ten demonstrated some ability to retain the newly learned information in long-term memory and the percentage of information retained from the training sessions varied from 83% to 49% of information. Participants both in the acute and

chronic stages of post-stroke recovery demonstrated the ability to learn new vocabulary. The two presented case studies demonstrate that despite the severity of aphasia new learning can occur. The training process involved participants taking time during each training session for independent rehearsal and consolidation of the newly learned words. Various tools and tasks were made available to all participants to use during this time if they so wished. However, the three participants with the lowest learning performance 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.

If new learning is a process involved in rehabilitation then speech and language therapists would need to consider the adaptation of therapy tools and methods in order to promote new learning processes in therapy. Qualitative data indicated that participants employed individual learning methods to promote their learning, such as, listening to audio recordings of the stimuli, writing lists of the new words, repeating the words aloud. The differing approaches by participants to learn the new vocabulary suggests that individuals approach the learning experience in different ways and choose methods most suited to their particular learning style. As people are thought to learn in different ways it may be that different learning techniques would facilitate language restitution in different individuals. Perhaps discovering the optimum learning strategy for each individual before embarking on the therapeutic process would identify the best methods to use during their rehabilitation. The use of learning concepts could revolutionise the rehabilitation of aphasia and promote the identification and establishment of optimum methods of learning to facilitate the highest potential restitution of language. Perhaps although the same stimuli might be used in rehabilitation, the 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 to individual patients. The design of an appropriate tool to aid the identification of individual learning style/technique preferences for people with aphasia is currently being developed and further studies will investigate if adapting therapy tools and procedures for each individual's particular learning style / technique can optimise rehabilitation outcomes.

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Appendix A
Five of the 20 novel words used in the investigation