

COOPER



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**PREDICTING FUTURE DYSGRAPHIA THERAPY?
THE APPLICATION OF A WORD PREDICTION PACKAGE TO AN ADULT CLIENT WITH
ACQUIRED DYSGRAPHIA AND A PLAN FOR THERAPEUTIC INTERVENTION**

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Abstract

Until recently Word Prediction Packages (WPP) had primarily been used with children with physical and learning difficulties. The application of WPP and other compensatory software to adults with acquired language disorders has revealed that there may be considerable functional gains to be made when using this strategy in aphasia therapy. This study sought to discuss how an adult with acquired dysgraphia, GK, could benefit from using a WPP (Co-Writer®). In order to do this, detailed investigations were made into his current skills. This included assessment of his ability to plan the content of his written language, his ability to transcribe and his revision skills. The results of the investigations suggested that GK would require considerable speech and language therapy support to become competent with Co-Writer®. However, his areas of strength suggest that a WPP has the potential to provide a compensatory tool to support his written output. As such, suggestions have also been made regarding the structure of a therapy study with GK.

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1. Introduction

In order to correctly establish the use of a word prediction package with a client with dysgraphia it will first be necessary to consider the nature of the disorder and proposed models of the writing process. Then the application of computers in aphasia therapy will be considered, firstly in a general sense and then, more specifically, how compensatory software packages have had an impact on therapy outcomes. Owing to the fact that the software package relevant to this study (Co-Writer®, a word prediction package) was primarily developed for use for those with physical difficulties in developmental settings, it will also be relevant to consider what its application in this context has revealed in terms of its impact on written output. Despite the fact that this package was originally intended for a different client group, there has been some application of such software to people with aphasia. The details of such research will also be discussed here. This study will propose how Co-Writer® should be introduced to an adult with acquired dysgraphia whose main aim is to be able to write again.

1.1 The underlying disorder

Dysgraphia can be defined as the “loss or impairment of the ability to produce written language caused by brain damage” (Benson and Ardila, 1996:212). At the single word level, according to cognitive neuropsychological theory, spelling to dictation is realised via either a lexical or a sublexical route (see figure 1). The semantic lexical route entails writing single words with access to meaning via the semantic system, or word store. Homophones, for example, ‘blew’ or ‘blue’, are spelled via this route as meaning is required to identify the correct spelling. A direct lexical route has been hypothesized which goes via the lexicons without access to the semantic system. The sublexical route (see the dotted line in figure 1) may also be referred to as the ‘sounding out’ route. When this route is used, the dictated word is segmented into phonemes which are then translated into graphemes allowing unfamiliar and non words to be written. If an unfamiliar word is being written via this route, for example when the semantic lexical route is impaired, successful spelling of that word will depend upon the degree to which the phonemes correspond to the graphemes of that word, or ‘sound-to-spelling regularity’. The English language provides a challenge for people who rely on this route as it has many irregular spellings, for example, words such as ‘yacht’ and ‘rough’ may be realised as ‘yot’ or ‘ruff’.

All of the described spelling routes converge on the graphemic output buffer. This may be described as a temporary store which holds the graphemic information of a word prior to its

realisation. From this point, spelling may be executed by a variety of means including writing, typing, rearranging individual letters or tracing words with a finger.

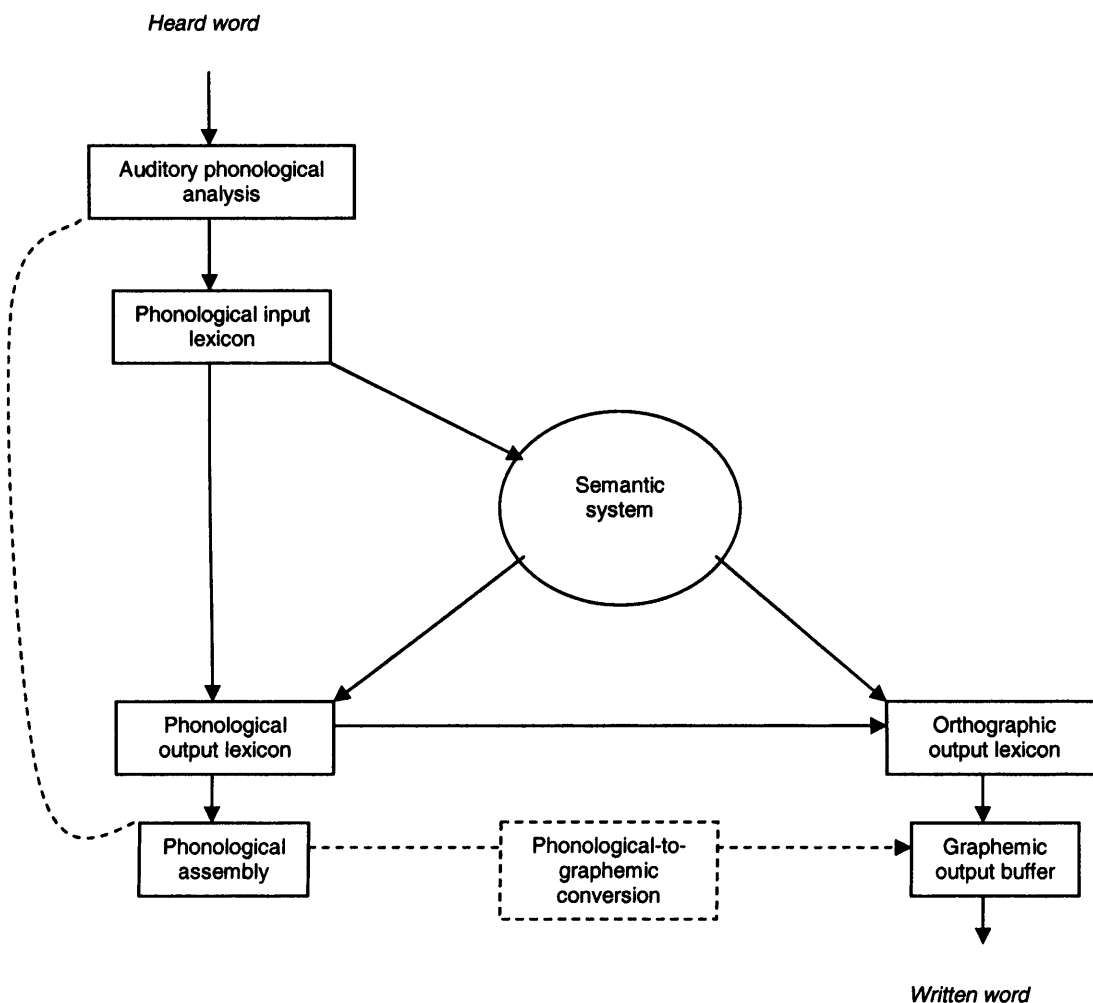


Figure 1: Writing to dictation (based on Whitworth, Webster and Howard, 2005).

A disruption can occur at any point in the spelling process. Therefore dysgraphia is a complex problem for the therapist to tackle, requiring psycholinguistic assessment of the client's existing abilities in order to provide relevant therapy which targets the impaired level of the spelling process.

Traditional cognitive neuropsychological approaches to spelling impairments can be aimed at lexical, sublexical spelling processes or an interactive use of the two routes (Beeson, Rewega, Vail and Rapcsak, 2000). Therapy for the lexical route might include item-specific reactivation techniques (Rapp and Kane, 2002 as cited in Whitworth et al, 2005) or relay strategies. Beeson et al (2000) describe their client's (SV) successful use of a relay strategy: SV had a set of key words which she consistently spelled correctly. When she could not recall a particular grapheme, for example 'k', she could recall her key word (Kim) and in turn

recall the correct grapheme. There is evidence to suggest that such techniques can lead to significant improvements at the single word level. However there is limited evidence to suggest that they lead to functional gains for the client wishing to write at the sentence level, for example when corresponding with family members (Beeson et al, 2000).

1.2 The writing process

While spelling at the single word level, as described above, is an essential part of the writing process, the production of written language also entails the formulation of thoughts and the construction of sentences. In their 1994 paper, Berninger and Swanson suggest modifications of Hayes and Flower's (1980) model of writing. The original model divides the writing process up into planning, translating and revision. The planning stage involving idea generation and the organization of thoughts. The translation stage can further be divided into text generation (converting ideas into language representations) and transcription (converting language representations into writing). Lastly, the revision stage involves evaluating and making amendments to the output. From developmental investigations of children learning to write, Berninger and Swanson suggest that translation develops prior to the planning and revision stages. It is their contention that once the translation stage becomes automatic, writers can dedicate more resources to the less well developed stages of planning and revising.

It may be possible to hypothesize, therefore that someone with dysgraphia could be directing the majority of their resources on the translation and transcription stage of the process and very little on the planning stage. Therefore it is important to consider the generation capabilities of an individual as well as their writing and spelling abilities in order to create a comprehensive profile of the writing process. It may be possible to hypothesize that a WPP could help remove the difficulty at the transcription level allowing more resources to be dedicated to the previous stages of the writing process.

1.3 The application of computers in aphasia therapy

Since the technological revolution has penetrated most spheres of life it was only a matter of time before computers and software packages had an impact on aphasia therapy. A computer may be of use to a therapist as a medium for delivering typical therapy tasks; it may also provide the means to facilitate intensive practice owing to the fact that, after training, therapeutic activities may not require therapist supervision. More latterly, software has been available to help provide compensatory strategies which aid the comprehension and expression of language.

In their 2001 case study Mortley, Enderby and Petheram use computers as a means of delivering therapy tasks and facilitating intensive practice. Mortley et al suggested that the use of a computer for intensive training was essential for the success of their intervention with MF, a client with acquired dysgraphia. The aim of the therapy was firstly to develop a spelling strategy. They then aimed to facilitate functional use of the strategy, progressing from the single word level to the sentence level. They believed that the computer allowed generalisation of their therapy to functional activities because it provided the opportunity for intensive practice. The use of a computer also increased MF's self-esteem and allowed him to develop independence. Later on in this same study, Mortley et al introduced an adaptive word processor to their therapy. This package was a word prediction package designed to speed up the process of writing. Mortley et al argue that the adaptive word processor allowed MF to concentrate on the strategy, thus removing the difficulties he experienced at the transcription level.

The adaptive word processor used by Mortley et al is a piece of compensatory software. For some time now, computer packages designed to enable the client to use their areas of competence to compensate for areas which require support have been available. These include computerised speech packages which allow the user to have written text converted into verbal messages (ReadPlease® and WriteOutLoud®), voice recognition packages which convert verbal output into written text (Dragon Naturally Speaking®) and word prediction packages which generate words based on the first letter entered into the programme (Co-Writer®).

1.4 Word Prediction Packages: current applications

All WPP work on the general principle that when a letter is typed into the program, a list of words will be provided beginning with that letter. The list will become more specific if more letters are typed. WPP were originally intended to assist individuals with physical disabilities, minimizing key strokes and therefore physical effort (Tumlin and Wolff Heller, 2004).

Increasingly however, they have also been used to support those with speech, language and learning difficulties in developmental settings in order to help manage planning and revising processes (MacArthur, 2000).

Studies carried out with developmental client groups have found that WPP provide effective support. When used with children with physical disabilities, WPP have been found to increase typing rate, decrease spelling errors and reduce fatigue (MacArthur; 2000; Newell, Arnott, Booth, Beattie, Brophy and Ricketts, 1992a; Wood, Rankin and Beukelman, 1997).

Thus the efficiency of their output may be increased as the WPP will reduce the number of key strokes required to type a word (Tumlin and Wolff Heller, 2004).

Newell, Booth, Arnott and Beattie (1992b) studied a WPP called PAL (Predictive Adaptive Lexicon) in a special educational needs setting. They found that after introducing the package with an individually tailored program, the 17 children who took part in the study reduced their spelling errors by 70 per cent when using the WPP as compared to word processing without the aid of prediction. The time taken to produce the work was also reduced.

When used with children with spelling impairments and language difficulties, WPP have also been found to help develop the quality of their written output. It could be hypothesized that when the user has correctly spelled and grammatically appropriate words at their disposal, they may then concentrate their efforts on constructing the meaning of the message they are trying to convey (Wood et al, 1997).

Newell et al (1997a) argue that the use of WPP can improve the quality of the text produced by children with developmental language disorders. Newell et al found that the syntactic structure of written output by children with learning difficulties improved with the use of PAL, particularly when teachers read the sentence back and the writer was able to detect any errors and correct them. Other WPP, for example Co-Writer®, offer users a read back facility as an integral feature.

The overall effects of using WPP with children with physical and learning disabilities has been to improve the speed, accuracy and quality of their written output. Furthermore, it has been suggested that WPP provided great motivation (Newell et al, 1992a) to those experiencing difficulties with the writing process.

1.5 The emerging use of WPP in aphasia therapy

The evidence suggests that WPP have been a very useful aid to pupils in the school environment. Based on what has been learned from the software's application to children with learning difficulties, it is arguable that WPP can make a considerable contribution to the rehabilitation of those with acquired dysgraphia. Newell et al (1992a) also suggest that language dysfunction in acquired disorders may benefit from the use of WPP. It is Newell's (1990) contention that:

“such a prosthesis would improve the quality of the written work and...provide substantial motivation (to users who would) be able to achieve far better written work using the prosthesis than without it” (1990:86)

As reported above, Mortley et al introduced a WPP to MF. Due to the fact that writing was very time consuming and laborious for MF even with a spelling strategy, the WPP was set up to speed up the writing process. The WPP firstly benefited the patient by providing instant feedback and therefore prevented mistakes being reinforced. Secondly, MF was able to use the package with minimal support, therefore increasing self-esteem. The therapy programme included encouraging the functional use of writing supported by the WPP by writing a diary and corresponding with a family member. This meant that he was able to use communicative writing in a functional way.

In another paper MacDonald and Armstrong (1998) investigate the efficacy of WriteOutLoud® (a package which provides computerised speech output of written text) and Co-Writer® (a WPP). They showcase the benefits that compensatory software packages can yield:

One of their clients (PW) initially presented with severe output difficulties at the sentence level. Without the help of a therapist or the computer programmes, PW was able to produce the following when describing action pictures. Each individual sentence took in excess of five minutes to type:

“a boy is ir.” (A man is ironing)

“the lady wo” (A lady was baking a cake)

One week later, the computer packages were introduced to PW and with some therapist support, he was able to produce the following:

“The lady is knitting a sweater”

“The lady is smelling the flowers”

PW then went on to participate in approximately 30 one-to-one therapy sessions using the computer packages. Activities included action and composite picture description and later, composition of a diary. The following was produced by PW in a session one year after the initial session:

“Today my daughter-in-law and son came to visit me. They came to have their tea with us. They brought some things with them”

MacDonald and Armstrong also document three other cases that show similar results when using WriteOutLoud® and Co-Writer® in conjunction with one another. The two packages were used together due to the fact the edition of Co-Writer® used in the study did not have a speech output facility. Their examples clearly demonstrate that if the person with aphasia has the linguistic competence, support at the level of transcription enables them to produce more substantial and complex written output.

Armstrong and MacDonald (2000) also describe a case study (MD) whose written output improved via use of the same two computer packages. MD presented with persistent spelling difficulties even after a number of years of therapy. Therefore the researchers employed the use of the software as a compensatory measure. After 12 therapy sessions, doing activities such as written picture descriptions using the packages, Armstrong and MacDonald describe an improvement in terms of quality and quantity of written output. After therapy, MD produced more words when typing and made fewer spelling errors. In the long term MD continued using the computer packages independently to aid functional writing tasks such as writing letters.

The evidence from the implementation of other compensatory packages suggests that use of computer software can have marked improvements on the communication skills of individuals with aphasia. Bruce, Edmundson and Coleman (2003) introduced Dragon Naturally Speaking® to MG, a man with fluent aphasia but considerable written output difficulties. The use of this ‘voice recognition software’ allowed MG to use his verbal output to compensate for his written difficulties. Bruce et al observed a considerable improvement in his written work. They also noted functional gains in his communication skills such as his use of the software to write shopping lists and emails to both family and healthcare institutions. King and Hux (1995) implemented WriteOutLoud® with Mr. C, a read-back facility in order to aid revision of his written work. They observed an overall decrease in error rate immediately after introduction of the package and after a period of therapy, his newly acquired skills also generalised to writing done without the assistance of the computer package. Therefore this evidence shows that other packages, designed to compensate for areas of weakness show the potential for functional gains during the rehabilitation process.

Traditional approaches to the remediation of acquired spelling and writing difficulties should not be considered redundant; however, a WPP may offer benefits to clients that conventional therapy may not. If the dysgraphia of a client is so severe that previous treatment has not

yielded satisfactory results but a client has the necessary skills for using such a package, it would seem illogical not to offer them such a package. The previously mentioned case of MD (Armstrong and MacDonald, 2000) had not made functional gains with traditional cognitive neuropsychological therapy for his written language difficulties. However the use of Co-Writer® improved the quantity and quality of his writing. Therefore based on the emerging evidence (Bruce et al, 2003; Armstrong and MacDonald, 2000; King and Hux, 1995), it could be argued that the use of compensatory computer packages may provide benefits at the functional level. As Armstrong and MacDonald (2000) point out computer software packages are functional aids rather than merely a medium within which to provide therapy. Previous studies on writing therapy have primarily concentrated on measuring therapy outcomes at the impairment level. Although difficult to quantify, the functional use of the packages should be the ultimate goal. After reviewing literature related to writing therapy, Mortensen (2004) found that the evidence base guiding therapists as to how to tackle functional writing tasks is currently very limited and calls on researchers to consider this when studying the effectiveness of therapy.

The evidence to support the use of such computer packages with people with communication difficulties resulting from aphasia is still growing, yet the outcomes have been positive. The evidence suggests there is considerable potential for using compensatory packages with people with aphasia, and the use of WPP may significantly augment written output in patients with dysgraphia.

1.6 Co-Writer®

This study will be looking at a word prediction package called Co-Writer®. As text is entered, the prediction package will offer a list of words based on the letters entered. As more letters are entered the options become more specific; the user is then able to select the desired word in the list and the program then enters the whole word. These packages are easily used in conjunction with normal word processing packages such as Microsoft Word.

Co-Writer® also allows the user to tailor a number of options to their needs. How a word is chosen from the list can be set according to the client's preferences, selecting via the corresponding number or the mouse. There is also a 'read-back' option allowing highlighted text to be read to the writer. Topic dictionaries can be selected making it more likely for certain subject-related words to be in the predicted list. These topic dictionaries can also be created and therefore relevant vocabulary can be saved. If a particular word is used more frequently then it is more likely to be predicted as the desired word, therefore the package

'learns' according to its user.

The profile of specific settings can be saved under user names and those settings will depend on the user's needs and disability. For example, a very long list of suggestions may be hard to read for some users; however, being able to accurately select a word from a list may be a particular strength for another individual therefore a longer list of words may increase the chances of the target word coming up.

1.7 What investigations should be made prior to use of a WPP?

Users of WPP should be able to generate ideas, know how to put words together in a sentence, be able to select the first letter of the word and be able to read and select the desired word from a list. Investigating a person with dysgraphia with the use of WPP in mind will involve careful analysis of their language generation capabilities, sentence construction abilities, spelling, particularly identification of the initial letter of a word, as well as written and auditory comprehension.

1.8 The current study

It is the purpose of this study to consider the pre-requisite skills required for Co-Writer® in relation to GK, a 51 year old man with mild receptive aphasia and severe expressive aphasia, and discuss what strategies and support should be provided when implementing this package. Taking Hayes and Flower's model as the basis of these investigations, the following questions shall be addressed when assessing GK:

- 1) Does GK have the ability to plan what he wants to write?
- 2) Does GK have the necessary sentence construction skills and transcription skills required to use Co-Writer?
- 3) Is GK able to detect errors in sentence level output?

2. Case Description

2.1 Background Information

GK is a right-handed, 51 year old male who has had two left CVAs, the first in January 2003 and the second in May of the same year. Brain scans taken at the time confirmed a large left middle cerebral artery infarct. These CVAs left GK with mild receptive aphasia, severe non-fluent expressive aphasia, severe verbal dyspraxia, and a right-sided hemiparesis. He also suffers from epilepsy. He currently lives with his partner and visits his mother daily who is motivated to participate in and support GK's therapeutic activities.

Pre-morbidly, GK worked as an accountant in the City. He was raised bilingually (his father being English and his mother French) and also spoke fluent German and Dutch. He was highly computer literate and was in the process of writing a novel prior to the initial CVA. GK is highly motivated to participate in therapy and has identified his overall goal as being able to write again.

2.2 Previous therapy and language recovery

GK has participated in individual and group therapy since immediately post-onset. Initially GK presented with mild comprehension difficulties but severe expressive difficulties. Since 2004 individual therapy has targeted his reading, writing and spoken language difficulties and GK made some progress in these areas. A report in 2005 highlighted the severity of GK's writing difficulties, stating this was limited to writing the initial letters of some words. Reading comprehension difficulties were also noted, GK taking 20 minutes to read a 200 word passage with 60% comprehension. A text-to-speech package aided both reading speed and comprehension, GK using ReadPlease® to read an equivalent passage in 8 minutes with 80% comprehension.

Group therapy has been aimed at developing his total communication skills. While GK has persistent difficulties with verbal output and remains non-fluent, he will often trace the initial letter of his target word on the desk or use gesture to convey meaning. He also has very good non-verbal skills, initiating topics and using humour.

The study GK participated in during 2005 and 2006 (Chilvers, 2006) aimed to re-establish his sound-to-letter mapping skills by using a key word relay strategy (as described by Beeson et al, 2000) to enable him to select the initial letter of a word on a computer keyboard. Pre-therapy investigations for the study (during 2005) revealed that both GK's lexical and

sublexical spelling routes were impaired. He had however, learnt to associate each letter of the alphabet with a key word picture/name. The aim was then to develop a keyword relay strategy. After therapy, it was found that when required to point to the initial letter of a dictated word (on a QWERTY layout letter board) GK's ability to do this significantly improved. Prior to intervention GK's score on a set of control words was 6/21; post-therapy this increased to 13/21 suggesting that these skills generalised to items not treated during therapy. There was also some evidence that generalisation occurred to other sound-to-letter matching tasks such as written picture naming.

2.3 Current investigations

Considering the fact that GK's speech is not fluent a package such as Dragon Naturally Speaking® would not be suitable for him. Co-Writer® is an appropriate package for consideration because previous therapy has targeted his ability to point to the initial letter of a word on a QWERTY layout letter board thus developing one of the prerequisite skills required to use Co-Writer®.

In order to successfully implement the use of Co-Writer® with GK, it was first necessary to run a series of assessments. Profiling his existing skills will reveal any areas which may need support.

2.3.1 Cognition

In 2005 GK scored 36/36 on Raven's Coloured Progressive Matrices (Raven, 1976) confirming that he has good non-verbal visual problem solving skills. Other cognitive investigations showed that GK has difficulties repeating strings of more than three digits scoring 4/14 on a short term memory (STM) test. These difficulties could be attributed to STM problems or to his spoken output difficulties.

2.3.2 Language

For the purposes of another research project, GK was assessed using the Western Aphasia Battery assessment (WAB – Kertesz, 1982) at the beginning of the study (see table 1):

WAB subtest	Score
<i>Spontaneous speech</i>	
Information content	10/10
Fluency	4/10
<i>Comprehension</i>	
Yes/No Questions	45/60
Auditory word recognition	43/60
Sequential commands	26/80
<i>Repetition</i>	54/100
<i>Naming</i>	
Object naming	45/60
Word fluency	4/20
Sentence completion	4/10
Responsive speech	4/10

Table 1: Results from GK's WAB

His aphasia quotient was 41.6 indicating GK has Broca's aphasia.

GK's spoken output was non-fluent. His picture description was:

“book...reading...coca cola....(points to radio) radio...dog and kite and flag and sailing and sand and tree and house and car... bag (pointing to basket).../bə mblɪŋ / (?paddling)...fishing”

GK was able to repeat single words, however his verbal output was effortful. As a result of his dyspraxia, for example it took him two attempts to repeat 'banana' and 'snowball'. At the sentence level, GK was only able to repeat the content words and as the sentences got longer, GK found them more difficult to repeat.

GK found the tasks more challenging as they became more complex, for example identifying right and left body parts (subtest B). For subtest C, GK was able to perform simple commands. For the more complex commands he was able to comprehend the content words of the sentence but not the function words: e.g. command: 'point with the pen to the book' response: points to the pen and the book.

GK's performance on the word fluency subtest (naming as many animals as possible in one minute) suggests that his ability to generate names under a specified semantic category is

considerably impaired. His ability to complete sentences and his responsive speech was also impaired.

2.3.3 Investigations into comprehension

Single word level comprehension

As previously shown by the results from the Auditory Word Recognition subtest of the WAB, GK's auditory comprehension at the single word level is relatively good. Owing to the fact that reading comprehension is an essential skill for using Co-Writer®, it was also necessary to confirm that GK had good written comprehension. Therefore the Reading Comprehension Battery for Aphasia 2 (RCBA-2, LaPointe and Home, 1998) was performed (see table 2). The RCBA-2 is an American assessment, therefore the materials were modified to reflect British vocabulary and spellings. His results were as follows:

RCBA-2 Part 1 Subtest:	Score:
I - Word-Visual	9/10
II - Word-Auditory	10/10
III - Word-Semantic	10/10
IV - Functional Reading	5/10
V – Synonyms	6/10
VI - Sentence-Picture	9/10
VII - Paragraph-Picture	7/10
VIII - Paragraph-Factual	9/10
IX - Paragraph-Inferential	4/10
X - Morpho-Syntax	6/10
XI - Letter Discrimination	40/40
XII - Letter Naming	1/40 – test terminated
Overall percentage	64%

Table 2: Results from the RCBA-2

Subtests XI and XII show that although GK is able to point to a letter when given the name he is unable to produce the names of letters.

GK's results for subtests I, II and III reveal that his reading comprehension at the single word level is also a relative strength, with the only error being a word that had an American spelling ('tassel' for 'tassle' which was missed during modification). His synonym subtest score (V) was relatively low making the following errors:

Item	Target	Response
5. Stay	Remain	Leave
8. Stop	Halt	Go
9. Instrument	Tool	Argument
10. Understand	Know	Unaware

Items 5, 8 and 10 are lower imageability words; GK selected a word that is semantically opposite to the target. It could be hypothesized that GK may have a semantic deficit for low imageability items. Therefore further investigations were made into his semantic representations at the single word level using the auditory and written synonym judgement subtests from the Psycholinguistic assessments of language processing in aphasia (PALPA tests 49 and 50; Kay, Lesser and Coltheart, 2001):

	Auditory	Written
High imageability items	28/30	29/30
Low imageability items	23/30	24/30
Total	51/60	53/60

Table 3: Results for PALPA subtests 49 and 50

Similar results were seen in both modalities, that GK was able to judge high imageability word pairs better than low imageability. Although this was only found to be significant in the written modality (written: $X^2 = 4.04$, $df=1$, $p < 0.05$, auditory: $X^2 = 3.27$, $df=1$, $p=0.71$) a central semantic impairment for low imageability items can be hypothesised.

Sentence level comprehension

Again for the purposes of another research project, GK's sentence level comprehension was assessed using the auditory comprehension subtest of the CAT (Comprehensive Aphasia Test; Swinburn, Porter and Howard, 2004) for which he scored 21/32. His errors suggest that more complex sentence structures (e.g. three argument structures like 'the flower under the cup is red') are more problematic for him to understand. This will be important to consider when selecting therapy materials for GK. His sentence level comprehension in the written modality (see table 2, subtest VI of RCBA-2) is a relative strength scoring 9/10. These sentence structures however, did not progress in terms of complexity and only one argument structures were assessed. Therefore further investigations were made into GK's sentence processing abilities.

During the writing process, it is essential that the writer is able to re-read and revise their output identifying whether a sentence is grammatical or not. It was therefore necessary to investigate GK's sentence processing abilities in the auditory or written modality for the purposes of using Co-Writer.

The Grammaticality Judgement subtest of the Philadelphia Comprehension Battery (Saffran, Schwartz, Linebarger, Martin and Bochetto, 1998) consists of two sets of sentences: the training set and the test set. Violations in the training set were simply either word order violations, for example 'the girl jumped the pool into', or marker violations, for example 'many person watched the game'. However in the test items violations were more subtle, for example verb complement clause violations such as 'I want you will go to the store now' and subject-auxiliary inversions such as 'was the girl enjoy the show?'.

In order to compare the two modalities the test was presented in both auditory and written forms. To control for order effects, the first half of the stimuli were presented aurally and the second half in written format in one session. To complete the assessment, this pattern was reversed in a subsequent session:

Philadelphia Battery Grammaticality Judgements Test		
Training set	Auditory presentation	Written presentation
'Good' sentences	9/12	9/12
'Bad' sentences	11/12	8/12
Total	20/24 (83%)	17/24 (71%)
Test items		
'Good' sentences	26/30	27/30
'Bad' sentences	26/30	9/30
Total	52/60 (87%)	36/60 (60%)

Table 4: Results for Grammaticality Judgements in auditory and written modalities

Across the two modalities, GK scored better on the training set where the violations were less complex than those in the test items.

For the test items, the McNemar test showed $p < 0.001$, $N=60$, therefore the frequency of correct responses from GK in the auditory condition was significantly higher than in the written presentation. As shown in table 4, in the written modality he made numerous false positive errors making 21 errors with 'bad' sentences. Therefore GK had greater difficulty picking errors when the stimuli was written, however, auditory input could support this area.

This will be of significant importance when using Co-Writer with GK and will be discussed later.

Discourse level comprehension

It was also considered relevant to investigate GK's understanding at the paragraph and discourse level. GK would require this level of understanding in order to successfully review his written output. Moreover, owing to the parallel between input and output, if there were problems at this level, it would be reasonable to hypothesize that he would have similar difficulties in terms of output.

In order to assess GK's paragraph comprehension and inferencing abilities in the auditory modality, he completed the Listening Comprehension subtest (Set A) of the Discourse Comprehension Test (Brookshire and Nicholas, 1993). This test requires the client to listen to five short stories and answer a set of eight questions at the end of each story. Four of the questions are about stated details and four are about implied details. Across the five stories GK scored as follows:

Stated:	17/20
Implied:	11/20

Chi-square values for this data shows that $X^2 = 4.28$, $df = 1$, $p = <0.05$, therefore GK gives a significantly higher frequency of correct responses to questions about stated ideas than those about implied information. This suggests he finds it significantly more difficult to infer information in the auditory modality

Subtests VII, VIII and IX (see table 2) examined the same skill in the written modality. Although he scores highly on subtest VIII (extracting factual information), GK scored lower when inferring information (subtest IX). Chi-square values for this data shows $X^2 = 5.5$, $df = 1$, $p = <0.02$, therefore GK gives a significantly higher number of responses when asked about factual information than when asked about inferring information. During these subtests he was observed to refer back to the paragraph in question to extract information; this strategy supported extraction of factual information but not inferencing.

2.3.4 Investigations into spoken and written output

As previously shown from his WAB results, GK's verbal output is non-fluent and characterised by verbal dyspraxia. In terms of his writing skills, GK has a right-sided hemiparesis and therefore uses his non-dominant, left hand for writing tasks. His output is legible but slow.

Action picture description

As Co-Writer supports output at the sentence level it was necessary to assess GK's sentence construction abilities. Twelve action picture stimuli were provided and for each of these GK was asked to describe what was happening in the picture. For example for a picture of a man laughing, the target output would be 'the man is laughing'. This was initially carried out in the spoken modality. (See Appendix 1 for GK's output during this task.)

Analysis of GK's output revealed that he is able to offer appropriate content words for his description for example, 'locking door' for the target 'the woman is locking the door'. However he is largely unable to construct a syntactically appropriate framework or select appropriate function words. This suggests that GK will require support when writing at the sentence level when using Co-Writer.

GK was next asked to write descriptive sentences for the same action picture stimuli:

Target	Response
The man is laughing	My la
The man is eating an apple	Man apple
The woman is writing a list	rap p

(the test was terminated at this point due to the severe difficulties GK experienced generating output).

GK found this task very difficult and persevered for a number of minutes before saying 'can't'. For the sentences he did write, he used his keyword strategy learnt from previous therapy to target the content words of the sentence. For example when writing 'laughing' GK segmented the first phoneme /l/, related this to his keyword (lamp) and wrote down the correct grapheme. However it is evident that GK is struggling to produce recognisable vocabulary when writing.

Picture sequence description

GK was asked to describe the Jogger sequence (a series of pictures depicting a man trying to get fit and suffering a series of accidents while jogging, hurting his knee and subsequently throwing away his keep fit guide). Please see Appendix 2 for his output for this task.

GK's output for this task shows that he is again able to offer content words but with minimal syntactic structure. His output here further supports the hypothesis that GK has difficulties processing sentences.

When asked to produce a written description of the same picture sequence, GK's output was limited to single words and was extremely effortful (please see Appendix 3 for GK's output).

Therefore in order to remove the planning stage of the writing process and focus on analysis of his transcription abilities, a short description of the same sequence was dictated and GK was asked to write it down (see Appendix 4 for GK's output).

Out of the 21 words in the dictated description, GK got ten initial letters correct and two whole word spellings. This task was also time consuming (approximately 15 minutes). He substituted four initial letters and he did not attempt eight. He was, however, able to copy the description without error.

Comparison of GK's spontaneous output and his output when the content was dictated shows that the former does not have any significant syntactic structure. The latter shows awareness of the structure of the dictated sentences where he has left gaps for words he is unable to write. Analysis also suggests that GK has more difficulties identifying initial letters of function words than content words.

Functional tasks

Considering GK's skills in relation to the Hayes and Flower's (1980) model of writing, it was necessary to assess GK's ability to plan the content of his output. He was presented with various scenarios designed to test what he would write during various functional writing tasks. As GK's ability to write is severely impaired, he was asked to do this task verbally (see Appendix 5).

The first scenario was writing a dinner invitation to a friend; GK offered some relevant information such as "party...date...time" and when asked how he would start the letter he

said “I want you to come”. However, GK required prompting on several occasions for more information. For example, the therapist also had to prompt him to give a location and an appropriate ending.

For each of the other scenarios the therapist had to offer prompts to elicit appropriate output, for example, when asked what he would write in a letter to a relative, GK said “hello....I* and C* and R**” (names omitted for confidentiality reasons) and then required a question in order to generate output; the therapist at this point asked ‘what have you been doing recently?’ and GK was then able to talk about his recent holiday.

The last scenario was a more formal writing activity of composing an email to National Rail Enquiries asking the times of trains from London to Birmingham. GK found this task more problematic and required many prompts to elicit a minimal amount of relevant information.

Formal assessment of output

In order to assess GK’s noun and verb retrieval skills he was formally assessed using the Object and Action Naming Battery (Druks and Masterson, 2000), for retrieval skills at the single word level and the Thematic Roles in Production test (TRIP; Whitworth 1996) for retrieval skills at the sentence level:

	Score
Object Names	32/50
Action Names	28/50

Table 5: Results from the Object and Action Naming Battery

TRIP results	
Target items correct	
Single words	25/35
One-argument structures (agent)	10/15
Two-argument structures (agent and patient)	25/40
Three-argument structures (agent and benefactive)	23/30
Verb analysis	
One-place verbs	9/15
Two-place verbs	11/20
Three-place verbs	4/10

Thematic completeness	
One-argument structures	8/15
Two-argument structures	8/20
Three-argument structures	0/100

Table 6: Results from TRIP assessment

GK presented with word finding difficulties at the single and sentence word level and his dyspraxia was evident throughout these tasks. For some target words he could not name, GK traced the initial letter of the word out on the desk, for example, 'f' for frog. For others he could not name he provided some semantic information, for example, 'horns' for devil.

At the sentence level, GK scored relatively highly in terms of the target items on the TRIP sentences (i.e. objects). However, in terms of assessing the appropriacy of his verbs and the thematic completeness of the structures, his scores decrease suggesting that his sentence processing at a more complex level is impaired.

To investigate GK's language generation skills, GK was asked to create sentences using sentence anagrams using stimuli from the TRIP. The target sentence was written and cut up into its component words, GK was provided the picture stimuli and asked to rearrange the words into a descriptive sentence. GK was able to rearrange two-argument structures scoring 100 per cent. Interestingly, GK extracted the content words first, ordered these and then placed function words around the content word, rearranging until satisfied.

However, he found it much more difficult to perform this activity for three-argument structures for example rearranging the words to say 'the woman's basket to the showing the cat' for the target sentence 'the woman's showing the basket to the cat'. When it became apparent that GK was having considerable difficulty with this task, he was provided with a sentence framework in order to aid his success, i.e. the function words were prearranged for him and he was asked to slot in the content words. He still encountered some difficulties even with the framework, producing 'the showing are children the sheep to the bread' instead of 'the children are showing the bread to the sheep'. However, he successfully rearranged the target sentence 'the woman's giving the shell to the baby'. This evidence suggests that he has sentence processing difficulties in terms of output at a more complex sentence level.

Transcription skills

When using Co-Writer it is essential that GK is able to type the initial letter of a word. GK was asked to type the words from his key word strategy developed during previous therapy to see

if he could identify the initial letter. In 2006, after a period of intervention aiming to establish a set of key words to support GK's initial letter identification skills, GK was able to write to dictation 26/26 of the initial letters of his key words and 13/26 whole word spellings.

GK got 25/26 of the initial letters correct only omitting 't' and 8/26 whole word spellings correct, for example he was able to spell bat, zoo and egg. (See Appendix 6 for results). Therefore we can conclude that GK's ability to map his key word to the appropriate letter on the keyboard has maintained since his period of therapy and that typing on a QWERTY keyboard is not problematic for him. His whole word score has lowered, however initial letter identification is the more important skill for Co-Writer. As the package is designed to support his whole word spelling, this skill is not of primary concern here.

2.4 Conclusions from assessment

The findings from the above assessments suggest that GK will require support at the planning stage of writing (Hayes and Flowers, 1980). When introducing Co-Writer® to GK he will need support to generate written output at the sentence level.

At the transcription level, his ability to map letters from his keyword to the appropriate letter has maintained. He was observed to apply this strategy when completing other written tasks. Therefore his key word strategy will support segmentation of the initial letter of dictated words for him to enter into Co-Writer. In terms of revision of his written output, his judgements of grammaticality were much stronger in the auditory modality than in the written modality.

His single word reading is good therefore he should have the skills to select the target word from the list of words that Co-Writer® provides.

3. Initial introduction of Co-Writer

It was considered an essential part of this investigation to introduce GK to Co-Writer in an informal session. It was decided that writing some short dictated sentences would be appropriate, considering the outcome of assessment. This task was performed firstly without the aid of Co-Writer then with.

GK produced:

Target	Output
My name is G*	I n is G*
I live in W*	I f in W*
I went on holiday	I a on so

(* indicates personal information omitted for confidentiality reasons; in this instance, GK was able to spell the target words in full)

It was observed that GK was having difficulty firstly with selecting the initial letter of some of the target words, only correctly identifying 50%.

Subsequently Co-Writer® was introduced to GK, by telling him how to open the package and attach it to a word processing programme. It was then explained to GK what he was required to do (see Appendix 7 for the instructions given).

The sentences were then dictated again, with therapist support:

Co-Writer output

My name is G*
I live in W*
I went on holiday

It is apparent even from this small sample that Co-Writer® considerably augmented GK's output. GK did however require some support when mapping the target sound to the letter. When identifying the words from the predicted list GK took longer to identify function words than content words. It was also noted that if the word did not appear in the list, he was unable to recognise this and required support to enter in more letters to refine the choices.

After this initial introduction it was deemed necessary to conduct further assessment into GK's ability to select a word from a predicted list, making comparisons between nouns, verbs and function words. It was also necessary to carry out investigation into GK's ability to apply his keyword strategy to help him identify the first letter of other words.

4. Further assessment

Having observed him using Co-Writer the following assessments were carried out in order to complete GK's language profile in relation to skills required for Co-Writer®.

4.1 Word choices

GK must be able to read down a list of words and select the word he wishes to use in a sentence. In order to investigate this, a task was designed to emulate the choices GK would have to make during use of Co-Writer®. For 75% of trials the target word would be present and for 25% of trials it would not. (See Appendix 8 for how this task was designed).

GK scored 33/60. Out of the 15 times that the target was not present, on 14 occasions GK did not identify that the word was not present and instead selected an incorrect word. On 13 occasions GK selected an incorrect word when the target was present. The support required to overcome this difficulty is discussed later.

The breakdown of results in terms of word type are as follows:

Word type	Score	Average response time (for correct answers)
Nouns	10/20	13.1 s
Verbs	15/20	13.2 s
Functionals	8/20	19.25 s

Table 7: Results for Choice Task

These results show that his selection of functionals is more impaired than nouns and verbs. His selection of functionals is also slower.

4.2 Sound to letter mapping

It was also necessary to ensure that GK was able to apply his keyword strategy to other words. His key word strategy is a method that was intended to enable GK to segment the initial letter of a word, relay that letter to a key word and then identify the initial letter on a keyboard. GK was also asked to type 'control' words which were matched to his key words by initial phoneme and word and syllable length by Chilvers (2006).

GK got 13 out of 21 initial letters correct and four out of 21 whole word spellings (see Appendix 9 for details of his output). There were five occasions where GK was also able to provide the second letter of a word despite not being able to spell the whole word, for example, 'ma' for map. Chi-square values for this data as compared to the results of his key word output ($\chi^2 = 8.80$, $df = 1$, $p = 0.03$, < 0.05), show that there is a significant difference between the key word and control word results. Therefore we can conclude that currently GK's key word strategy is not generalizing. However, after the aforementioned period of therapy during 2006, GK scored 19/21 (initial letters) and 6/21 (whole word spellings), suggesting that with support GK is able to generalize his key word strategy to the initial letters of other words. This will be important when considering what support he will need in order to be able to use Co-Writer®.

GK was then asked to write his key words using Co-Writer®; again, his output was hugely improved with its aid (see Appendix 10 for the results of this assessment). Prior to using Co-Writer, GK got 25 out of 26 initial letters correct and eight out of 26 whole word spellings correct. With the aid of Co-Writer, GK scored 26 out of 26 initial letters correct and 24 out of 26 whole word spellings correct.

The McNemar test showed $p < 0.001$, $N = 26$. Therefore GK's whole word spelling is significantly better with the aid of Co-Writer than without i.e. there is a significantly higher frequency of correct responses in the Co-Writer condition than in the unaided condition. This provides some evidence to support the implementation of this package with GK.

4.3 Conclusions from further assessment

Further assessment revealed that GK has difficulties recognising when the target word is not present in the choices offered by Co-Writer. He also found it difficult to select the correct word when it was present in the list. In order to use the package successfully, this skill will need to be improved and will be discussed further below. Using his key word strategy to map sounds to letters was not always successful. However, it has been shown that with input in this area GK's skills can improve.

5. Discussion

In this section, the findings from assessment will be discussed in relation to the Hayes and Flowers model of writing and some general recommendations made regarding the therapy GK will need. The design for a single case study which aims to help GK use Co-Writer will then be proposed.

Investigations into GK's abilities highlighted potential difficulties at all three stages of the Hayes and Flower's model. Investigations into GK's planning skills revealed that he is able to offer some content for hypothetical written tasks. He did however require prompting from the therapist, especially with more formal written activities, therefore he may need some support in this area.

In terms of transcription, to use Co-Writer® the user must be able to type the initial letter of a word. GK's skills in this area are currently in need of support. Although he was able to type 25 out of 26 initial letters correctly of his key words, he found it more difficult however to type the initial letters of control words scoring only 13 out of 21. However, previous therapy undertaken as part of another research project indicates that GK will be able to regain initial letter identification skills with intervention. Chilvers' study (2006) showed that post-therapy, GK's abilities in this area improved significantly.

During therapy, Chilvers encouraged GK to use a keyword picture board to explicitly map from the first sound of the target to the appropriate keyword and so help him establish the strategy. The measures taken immediately post-therapy indicate that GK was internalising the strategy successfully. However the current investigations suggest this has not maintained. Therefore it might be useful to provide GK with a picture board of his keywords during his tasks with Co-Writer® to aid his use of the strategy . It will also be necessary to ask GK's mother to perform the homework tasks previously carried out as part of that therapy to support this skill.

This study also made preliminary investigations into GK's skills at the revision stage. It was found that he was able to detect simple word order violations. However his ability to detect more subtle grammatical errors was found to be significantly more impaired in the written modality than in the auditory modality. This would suggest that he would require the 'read-back' facility of Co-Writer® activated to compensate. This however, poses its own problems: the read-back facility is only activated once the written sentence has been transferred to the document it has been attached to. Investigations may have to be made into GK's ability to operate this and his ability to correct any mistakes with these constraints. The investigations

made into this area during this study were limited therefore it may also be necessary to make further investigations, such as into his ability to correct grammatical errors.

The choice task designed for this study revealed that he had difficulties selecting his target word and recognising when the target word was not present. Therefore GK will need input regarding word choices: this may involve therapy tasks designed to target this. However, Co-Writer® will also be able to support this to some extent. Co-Writer® is able to 'learn' the vocabulary that is used more frequently and topic dictionaries can be activated to make it more likely for relevant vocabulary to come up. Topic dictionaries can also be tailor-made and this can be done in collaboration with GK. It may also be appropriate to investigate if he is better at choosing words if he uses the read back facility to read each of the words in the list aloud to him. This was not addressed in this study but it could be an area of further investigation.

His writing at the sentence level will also be in need of support. Investigations show that his sentence processing abilities are currently impaired. Therefore, it will be appropriate to start with dictated material to support GK at this level. During therapy sessions it would be appropriate to introduce a subject that is of interest to GK and formulate some sentence material with him. The therapist would then dictate a sentence with reference to that topic. This would help remove the cognitive load associated with the planning stage of writing. GK has shown that he has some skills in terms of constructing one and two argument structures: he was able to construct up to two argument structures from sentence anagrams. As he becomes more familiar with the package however, sentence construction therapy may be appropriate in order to build on his existing skills.

5.1 Recommendations for future therapy

As previously discussed, it is hypothesized that someone with dysgraphia may concentrate more resources on the transcription level of the writing process than on the planning stage. When GK is able to use the package it may be that he is able to direct more resources to generating the language and less on the transcription stage. Therefore the transcription stage will be the first stage to be targeted during therapy.

Phase 1:

The first phase of therapy with GK will aim to make him a competent user of Co-Writer®. A structured therapy plan will be necessary to achieve this, with pre and post-therapy

measures to evaluate its success. A therapy study which measures the effectiveness of intervention using Co-Writer® would ask the following questions:

- 1) Does GK have the necessary skills to operate a computer for example, open the package and connect it to a word processing document?
- 2) Does Co-Writer® significantly increase the quality of GK's whole word spelling at the sentence level?
- 3) If so, does this generalise to GK's written output without the support of Co-Writer®?
- 4) Does Co-Writer® significantly increase the speed of GK's sentence level output?
- 5) Does GK's ability to select the target word and recognise when the target word is not present improve?

In order to answer these questions the baselines and outcomes that should be taken are as follows:

- 1) A checklist ensuring that GK is able to:
 - a) open the package
 - b) connect Co-Writer® to the document he wishes to transfer its output to
 - c) transfer the text with the appropriate mechanisms
 - d) use the read-back facility where required
 - e) save documents

A scoring system could be applied to this checklist: 2 = can do independently, 1 = can do independently after instruction, 0 = needs aid after instruction. Hopefully post-therapy he would be mostly at 2.

- 2) A set of action pictures with corresponding descriptive sentences should be dictated to GK pre and post therapy. This should be done firstly in an unaided condition i.e. without the aid of Co-Writer® and then with the aid of Co-Writer®. The vocabulary used should be controlled for phoneme-to-grapheme correspondence based on the key words used for GK's relay strategy. Under Co-Writer® conditions a record should be made of what GK enters, whether Co-Writer® gives him the word and whether he selects that word. His handwritten sentences should be scored according to the number of first letters correct and the number of whole word spellings. Repetitions of the sentences should be allowed however, it would be useful to record how many repetitions he required in each condition. These sentences should remain untreated throughout the course of therapy.

- 3) Post-therapy measures taken of the untreated sentences without the aid of Co-Writer® will show whether or not the skills gained through the use of Co-Writer® have generalised to his ability to write sentences.
- 4) The time it takes GK to write these sentences should also be recorded to answer question three.
- 5) In order to answer question five, a choice task similar to the one carried out as part of this therapy will provide a baseline measure with regards to this skill. The post-therapy measure for this may be problematic owing to the fact that Co-Writer® 'learns' vocabulary used more often and the choices will therefore be different during the post-therapy investigation. This may be overcome by doing the outcome measure as a 'new-user' (i.e. under the same conditions as the baseline measure). However, it is arguable that this does not reflect the benefits Co-Writer® has to offer. Therefore it may be useful to take outcome measures under both conditions and compare these as well.

As previously discussed, therapy would begin with developing GK's ability to operate this package. It would be appropriate to quickly move onto generating some topic ideas with the therapist dictating sentence level output. During the therapy, sound-to-letter mapping, word choice, speed of text entry and his ability to contribute to the generation of sentence level material should all be monitored and recorded session by session. His keywords remain well established but application of the strategy has not maintained at the level achieved in the previous therapy study. To help GK internalise his key word strategy, a picture board of his keywords should be present. Homework activities developing this skill would also be appropriate (see Chilvers, 2006). Similarly, it may be appropriate to develop some tasks designed to help GK recognise when the target word is not present in the list and build on his ability to choose the correct word.

Phase 2:

After reassessment shows GK is competent using Co-Writer® to transcribe at the sentence level, he should be moved onto functional writing tasks. He will require support in terms of formulating the content of his written work. The therapist could set GK some written tasks supporting him with a framework regarding content. GK struggled when 'writing' to National Rail Enquiries therefore a framework might be as follows:

- 1) who will you write to?
- 2) information they need to know, for example, where you are going and when you want to go

- 3) information you need to know, for example, the time of the trains and the price of the ticket
- 4) how should the letter be finished

Mortensen (2004) has referred to the fact that there is a shortage of studies which address the functionality of writing in adults with acquired language disorders. She argues that "it is increasingly relevant in a technological society where contexts for writing are expanding" (p.20). Therefore a therapy study should also aim to consider GK's functional use of writing and whether Co-Writer® is able to support more functional written activities. This may prove to be difficult to measure, however a questionnaire designed for the purposes of the study may go some way to providing a baseline measure to compare against after a period of intervention. The therapist should aim to identify written tasks which are relevant to GK, for example, corresponding with family members. Then a framework for the content of his written output should be provided as discussed above.

Armstrong and MacDonald believe that "generalisation...can only be achieved when client's have the technology at home" (1998:17). One of their clients who was most successful with the package had the package installed at home and the support of a family member during tasks. Therefore it would be appropriate to install Co-Writer® on GK's home computer and set homework tasks for him to complete. These can be carried out with the support of his mother who, as previously mentioned, is very motivated to help with GK's therapy.

5.2 Conclusion

This study aimed to consider whether a WPP would be a viable option for an adult with acquired dysgraphia. After careful consideration of the way in which WPP have been applied to other client groups and their potential uses to GK, detailed investigations were carried out into GK's current skills. Subsequent to these investigations, Co-Writer® was introduced to GK and further investigations were made into skills that were particularly relevant to using Co-Writer®. As such areas which need supporting have been identified and a proposal made for how to introduce Co-Writer® to GK in a formal block of therapy. It is hoped that Co-Writer® will enable GK to carry out functional written tasks and achieve his personal goal of being able to write again although this will require a considerable amount of therapy support.

Word count: 9982

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Appendix 1: Spoken action picture descriptions

- 1) Target: The man is laughing
Output: Laughing at man
- 2) Target: The man is eating an apple
Output: Eating apple
- 3) Target: The woman is writing
Output: Writing down words
- 4) Target: The man is brushing his teeth
Output: Brushing teeth
- 5) Target: The woman is washing her face
Output: Water and...face
- 6) Target: The woman is having a bath
Output: Relaxing
- 7) Target: The woman is reading (a book)
Output: Book...woman wri...reading
- 8) Target: The man is undoing his tie
Output: Man undo tie
- 9) Target: The man is cleaning a dish
Output: Man washing...round round round (gestures)
- 10) Target: The man is throwing a paper plane
Output: Man dart
- 11) Target: The woman is locking the door
Output: Locking door
- 12) Target: The woman is tying a parcel
Output: Woman tying

Appendix 2: Spoken Picture Sequence Description

“Keep fit...belly...oh god...up and running and...laughing ha ha and tired and tired and oh god...dog over and rain and falling can...keep fit...blowing nose...pain and”
(points to knee and bin)

Appendix 3: Written Picture Sequence Description

Hypothesized target	Output
belly	pale
keep fit	keep fit (copied from picture)
running	renn
laugh	lof
pain	pin

Appendix 4: Dictated Written Picture Sequence Description

Target	Output
A man has put on weight	A man h_ p_ _ r_
He goes jogging	_ _ jo_
People laugh	P_ l_
He trips over	_ _ h_
He hurts his knee	A_ ha_ _ t_
No more jogging!	_ _ j_

Appendix 5: Spoken output for functional tasks

Task 1: Writing a dinner party invitation (prompts by therapist in brackets)

Output: "Party...date...time"

(what time might you have a dinner party?)

Writes 7pm

(How would you start the letter?)

"Come...I want you to come"

(Anything else?)

"Dress smart...how to get there"

(How would you finish it off?)

G* and M*

(* personal information omitted for confidentiality reasons)

Task 2: Writing a letter to a family member

Output: (How would you start the letter?)

"Hello, I*, C* and R*"

(What have you done recently that you could tell them about?)

"Holiday...Swanage...driving...Epping...car...boat...2 miles...go on ferry...back car"

(What did you do there?)

"Eating...watched rain...train backwards and forwards...scenery"

(How would you finish off the letter?)

"See you...take care...M* and G*"

Task 3: Writing a letter to National Rail Enquiries to find out the times of trains from London to Birmingham

Output: "Hello...could I take...time...tickets"

(Where are you going to?)

"To Birmingham"

(Where are you going from?)

"From London"

(How would you finish the letter?)

"Bye Bye...G*"

Appendix 6: Output for keyword task

Target	Output
Sun	Sun
Man	Ma
Dog	D
Ant	A
Egg	Egg
X-ray	x-y
Rat	rat
Pig	p
Lamp	la
Hat	hat
Car	car
Gun	g
Umbrella	u
Zoo	zoo
Wig	w
Orange	off
Fan	f
Bat	bat
Yo-yo	yoi-yoi
Jig	jih
Tie	& (said "leave it")
Ink	i
Van	van
Queen	qut
King	k
Net	nat

Appendix 7: Instructions for Introduction to Co-Writer

- 1) type in the first letter of the dictated word
- 2) read down the list of words provided by Co-Writer and select the required word by clicking the cursor on it or typing the corresponding number
- 3) if the target word was not in the list GK was instructed to give another letter if he could in order to give the WPP more information from which to predict the target
- 4) once the sentence was completed, enter a full stop and the sentence will be transferred from Co-Writer to the word processing programme

Appendix 8: Method and Procedure for Choice Task

The task was designed using the noun, verb and functor word lists from PALPA 32 as these are matched for word length, syllables and word frequency. Using these lists would allow comparisons to be made between word types.

To set up this task, the initial letter of the target word was entered into Co-Writer® in a sentence context (see below for the sentences used). If the word did not come up in the list, up to two more letters were entered. The list Co-Writer® offered was then recorded to later be presented to GK. If the word did not come up in the list after three letters were entered, this target word was chosen as one that would not appear in the list offered to GK. The list of words offered at that point was then recorded. After this method was applied, the number of items that were omitted from each subset of words was not equal; therefore other words were chosen to not be included at random so that five words were left out of each subset. Each of those target words were removed from the lists to be presented and substituted with another option.

The predicted list of words (five choices) were shown to GK in a numbered list format and he was then asked to select the target word if it was there. For example:

Target (present)	Choices	Target (not present)	Choices
Career	1. Care 2. Carry 3. Careful 4. Career 5. Careers	Appear	1. Apologise 2. Appeal 3. Appealed 4. Apply 5. Approve

The word was given verbally and GK was asked to point to its corresponding number. The accuracy of GK's response and the time taken were recorded.

Sentences

The rabbit will appear out of the hat.

The people will suffer as a result.

It is wrong to do that.

It is not proper to do that.

His ability shone through.

Where art thou?

His career was on the rocks.

It was a serious offence.

Neither Will nor Dan went.

He created a scene.

I will meet you there.

The latter was not correct.

The welfare of the children was paramount.

He was a hero.

She felt happy.

He was not able to write.

It was a severe blow

He was unable to follow.

It was something nobody could predict.

He gave her grief because of it.

The bus was red.

The fog will be dense.

He had infinite wisdom on the subject.

From whence they came.

They did not expect to arrive on time.

The entire office was involved.

It was not a concept he was familiar with.

It was an iconic image.

It was a disturbing sight.

The image was superimposed onto a background.

Meanwhile the others walked home.

It was of a considerable size.

They visited an ancient ruin.

There was a large amount of soil.

His shoulders were very broad.

She was unable to speak.

The chilli burnt her mouth.

The hot wash made her top shrink.

The bombers were sent in to destroy the town.

It was a hard task to perform.

Peter would not listen.

I hang my clothes out to dry.

Sometimes I run to school.

I like to give myself a treat.

She could not describe how she felt.

I knew I'd do it somehow.

I could not hear the cat outside.

She would go on to develop a keen interest in it.

I have no opinion.

They could hear the bell toll.

You ought to be inside now.

It was her role to do the filing.

What else is to be done?

The sunflower wouldn't grow.

She couldn't carry it.

He was unable to agree with her.

She was a gentle person.

The house had damp.

He was well-off by virtue of a large inheritance.

The road was wide.

The jeans looked none the better for having been washed.

It was beneath the book.

He had to meet a client for lunch.

He seldom exercised.

He had to ignore his cravings.

He was a very handsome man.

He thought he was right but maybe he was mistaken.

She was a regular swimmer.

The art was selling fast.

It was something she had to do despite her feelings.

It was a long drive hence their hunger when they arrived.

It was an upward climb.

She had two boxes plus a bag of food.

They went onto the upper decking.

They were equal in status.

They had not considered how hard the task would be.

It was a tragic accident.

He thought that anyone would be able to do it.

She was unable to build it.

She kept herself warm by the fire.

Appendix 9: Control Words typed output

Target	Response
Vase	fa
Map	ma
Door	t
Elbow	h
Igloo	y
Leg	l
Toe	p
Web	w
Ring	r
Axe	x
Cat	cat
Hand	h
Key	key
Nose	no
Zip	zip
Pin	pi
Bed	p
Girl	c
Saw	sa
Jug	ju
Fish	fish

Appendix 10: Keyword output with Co-Writer®

Target	Output with Co-Writer
sun	sun
man	man
dog	dog
ant	ant
egg	egg
x-ray	x-ray
rat	rat
pig	pig
lamp	lamp
hat	hat
car	car
gun	gun
umbrella	umbrella
zoo	zoo
wig	wig
orange	orange
fan	fan
bat	bat
yo-yo	yo-yo
jig	ju
tie	tie
ink	inks
van	van
Queen	Queen
King	King
Net	net